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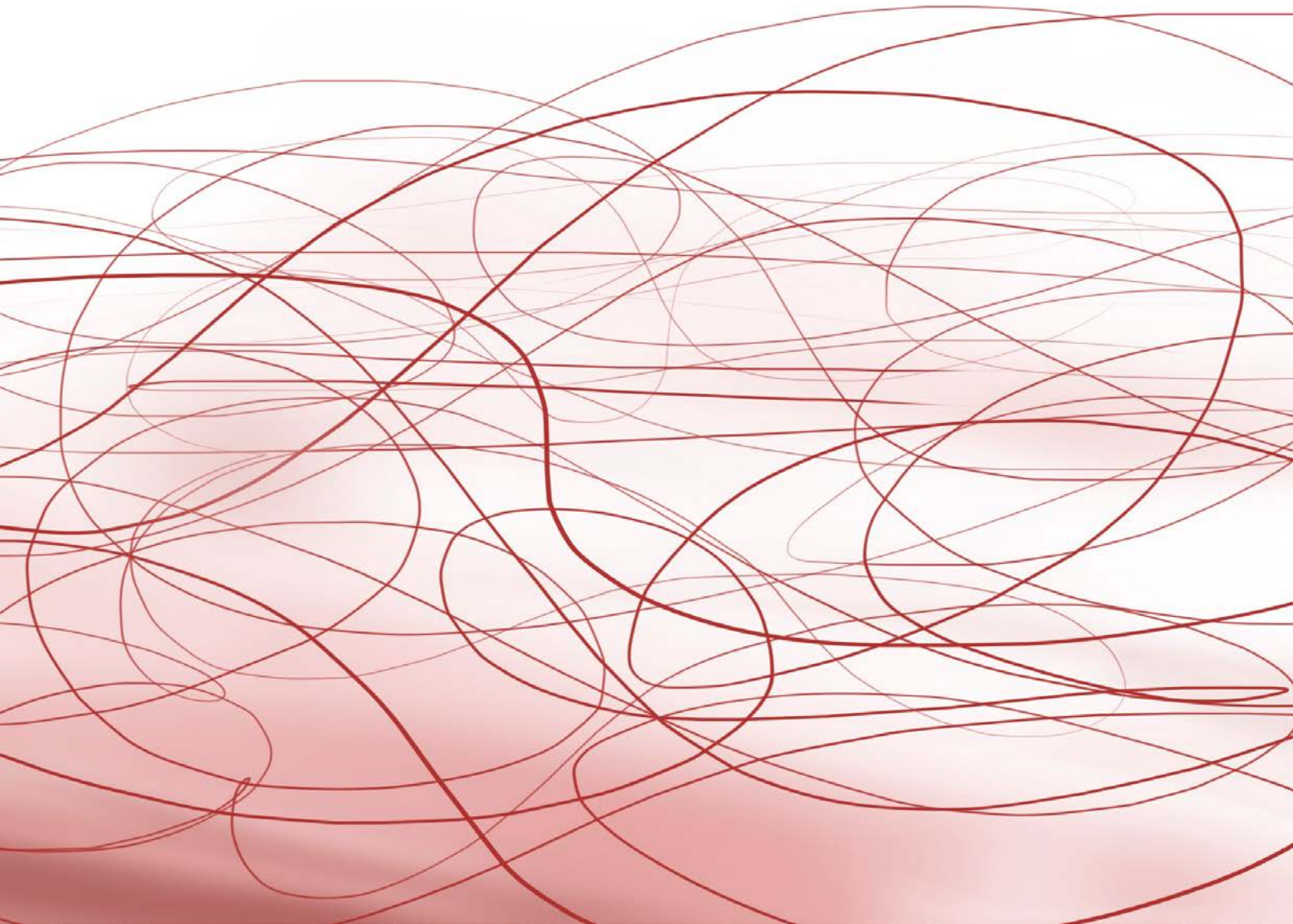

# Journal of Accessibility and Design for All

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# A PLATFORM TOY FOR CHILDREN WITH SPECIAL EDUCATIONAL NEEDS

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***Abstract*:** In childhood, play is critical to the successful development of children, and it can be regarded as the most important activity in their daily life, allowing interaction and discovery of the world around them. Consequently, it is important to ensure that this birthright is protected and accessible to every child, including those with special needs. Professionals, such as therapists, are often in a position where they can take advantage of the inclusion of toys in their therapies with children. Although, toys are not alike, and they must be carefully thought to be able to fulfil the child's needs. This paper presents a proposal and the first validation of an inclusive toy, entitled "HugMe", developed and designed with special attention for children who have cognitive and motor impairments and continue to be appealing to all children.

***Keywords:*** Industrial Design; Special needs; Adapted toy; Child; Inclusive Design.

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## Introduction

Play is the first way a child interacts with the environment. Playing has been increasingly explored and studied in the scientific field to be able to identify its benefits and clarify the connection between physical and cognitive development, intervening in the education and learning processes of the children. The play offers a basic structure to cope with a child's needs and awareness. It takes into account the actions in the imaginary world, the creation of voluntary intentions, constituting an intrinsic motivation and an opportunity to interact with others, in particular with other children and child's parents - these interactions will contribute to the child's development (Queiroz, Maciel, & Branco, 2006). Play allows children to use their creativity while developing their imagination, dexterity, physical skills, and cognitive and emotional strength (Ginsburg, 2007).

During a child´s development, play goes through several changes since the nature of play depends on the understanding of the environment, the need to act, the accessible objects, and the need to relate to the adult's world. As a case study, Martinez (2007) states that play can also be established as a motivational strategy, becoming a way for the child to demonstrate its physical abilities voluntarily. The study observes this by noting the child's positive expression during play, thereby verifying elements of its personality when playing (Martinez, 2007).

All children play, and they enjoy being able to create, to imagine their games which makes them capable of developing healthily. Nevertheless, not all children hold the same physical and cognitive capacities, making it difficult to follow and play with some existing toys. A child with a disability, despite having special needs, is first and foremost a child (UNICEF, 1999).

Throughout the time, studies of the importance of play in children with disabilities have increasingly become a popular area of research, particularly how play can relate to later competences in social and academic skills. Children with certain disabilities exhibit the same development play

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sequences but with some qualitative and quantitative differences (Azatyan & Asoyan, 2017).

In each impairment, physical, cognitive, or both, one can distinguish different degrees that can go from lighter to more severe, thus interfering with the child's ability to interact with the environment and others. If a lack of play occurs due to a child´s physical disability (at the sensory and motor levels), he/she becomes inevitably deprived of the experience of playing with certain toys. As an example, children with a visual impairment will not be able to experience a toy with lights or colours, and for children with hearing impairment, a toy with voices or sounds is of no use. Then there is an obvious need for alternative toys (Missiuna & Pollock, 1991).

For all children to appreciate the play, becoming in that way a more inclusive play, we need to offer the opportunity to let them play what they like to, and there are prepared for. We should support them in the process by reaching the level of challenge that allows them to have fun and pleasure together or with their peers and with adults of their life environment (Besio et al., 2018).

Play in an inclusive context has more facility and opportunities to share context, intentions, rules, objects, test abilities, imitations, and even refuse to play. Children should have the opportunity to express themselves without judgment. Play can fully develop the children's sensory, motor, social, communicative, and cognitive skills. Any kind of impairment (intellectual, sensorial, motor or socio-communicative) may severely delay the social and cognitive development of a child (Besio et al., 2018).

The limitations on the opportunity to play should be considered as important as any barrier in the child’s development, and play should be seen as a form of development. Children who have disabilities do not engage the same way in play activities as typically developing children do, they have fewer group interactions, and also they do not play with the same kind of materials (Azatyan & Asoyan, 2017). For children with special needs, the lack of materials according to their limitations increases the risks of their correct development (Ruffino, Mistrett, Tomita, Poonam, & Mistrett, 2006). This may disturb the social interaction of impaired children, increasing the risk of isolation (Missiuna & Pollock, 1991). So, there is a need for children to be able

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to interact with other children in an environment where they feel comfortable. Here, it is crucial to the commitment of parents (first and foremost) and child therapists. Therapists can develop and maximize the opportunities of children with special needs in playing in different contexts, being aware of and understanding the child's disability and thus, being able to help (Missiuna & Pollock, 1991).

With the increase of studies with children with disabilities, niche projects have risen, like social robotics for autistic children, adapted toys for children with cognitive and motor disabilities and accessible playground areas. This causes awareness of the importance of giving children the opportunity to play despite the disabilities they may have, putting play at the centre of multidisciplinary research and innovation concerning children with disabilities (Barron et al., 2017).

Vygotsky (2000) exposes that whenever there is a play, there are rules - not rules formulated to achieve a goal, but rules that are happening in the course of the play. Unguided playing without any restriction is the first approach to playing with the toy, to begin to explore by themselves their skills, experience objects, make decisions, understand cause-effect, apprehend, and understand adjacent consequences, all in an unguided toy approach. If children with special needs are not free to play without guidance, there may be an increased dependence on others and a decreased motivation (Missiuna & Pollock, 1991). It is also used as a booster, referring to the work of Brodin (1999), which writes that playing comes before toys and that children do not play because they have toys; toys are just a tool to facilitate playing (Brodin, 1999). With advancing age, there is an underlying change in the motivation and interests of the child, showing that its centre of interests will modify (Vygotsky, 2000), regardless of being children with or without special needs, thus the toy must also be adapted to the children age.

From the research undertaken, children with special needs should have toys that fit their needs so that they can play. Taking this into consideration, this paper presents a proposal for an inclusive toy designed from scratch entitled “HugMe”, aimed at different activities, with adapted accessibility that enhances play for all children and covering different forms of play.

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The paper is organized into eight sections. The section Participatory Research, presents the research among professionals and therapists to understand the necessities and difficulties for children with special needs in a play scenario. The collected interviews present important information about the playing, in children with motor limitations who became the focus of the whole project. Section Theoretical Assumptions presents the standard anthropomorphic measurements considered in this study for 3 to 6 years old children. The toy proposal is detailed in section 4, showing the elements that will be part of the toy, as well as the surrounding technology - an explanatory table to facilitate the acquisition of the product and an image with a drawing of the toy is also presented. Section 5 presents HugMe, the proposed toy prototype. Usability tests are detailed, followed by "HugMe" improvements. Finally, section 8 concludes with the final remarks.

## Participatory research

To better understand the importance of playing in children with special needs, a survey (in the form of interviews) was conducted among professionals to understand how they act in their therapies and what are the needs and difficulties of children at playing. Furthermore, it allowed us to explore the need to create a toy for children with special needs and understand how important an adapted toy is.

Occupational and speech therapists and psychologists were interviewed, as they are the most frequent health professionals in child's interventions in institutions, schools, or even at home. Some parents were approached to be part of the questionnaire, but they did not feel comfortable answering the questions after the first attempt to speak with them. Due to the children ages that the toy is directed to and their disabilities, the children could not express themselves what they need and feel. Only people who were close to them could, particularly therapists and medical professionals. The professionals who participated in this interview volunteered after contacting with the institutions. The professionals work in different associations with the main purpose of enabling the rehabilitation of children/adolescents. The Portuguese associations that participated in the study were: APAC (Association

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of Parents and Friends of Children, in Portuguese “Associação de Pais e Amigos de Crianças”); APACI (Association of Parents and Friends of Handicapped Children, in Portuguese “Associação de Pais e Amigos de Crianças Inadaptadas”); SalusLive; APPCDM (Portuguese Association of Parents and Friends of the Mental Impaired Citizen, in Portuguese “Associação Portuguesa de Pais e Amigos do Cidadão Deficiente Mental”); and APPC (Porto Association of Cerebral Palsy, in Portuguese “Associação do Porto de Paralisia Cerebral”).

The interview was done with 4 psychologists, 6 occupational therapists and 4 speech therapists with around 6 years of work experience. All the professionals gave their consent to participate in the study.

The structure of the interview had 3 parts:

- Play, to understand how children play and how the professionals direct the children in play;
- Stimulus, to indicate the most used stimulus on children and if and how the parents are included in the therapy;
- Toy, which materials they use and if they have to access to toys specially designed for children with disabilities and the needs for a new toy.

In short, from the interviews, it was possible to realize that therapists are focused primarily on helping the child to increase the use of the function of playing, with toys or without them.

One of the first pieces of information that can be seen is that there are two ways to approach playing, one in which playing is unguided, playful; and the second in which playing focuses on reaching a goal, where the latter is the one most used in a therapy context. It is said that if playing is inserted more playfully there is no need to establish strict rules, thus, there is no need for children to reach a goal.

Referring now to play in the therapy context, all professionals reported that the toy for children to play is always an auxiliary instrument, never an end by itself but help to an end. In some cases, professionals use the toy to achieve a goal to increase children’s motivation in the activity, always following the

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development milestones, the level where they are, their needs, and the intended goals. It is worth noting that the goals are established by therapists and the family.

The participants referred to an interesting example that reinforces the fact that the toy is an important auxiliary tool. In some cases, for the therapy to be effective, there is a need to place the child in an upright position. For a child who has limited mobility and its natural position is seated, this can put the child in discomfort or even in pain. By bringing in a toy or object that might be of its interest, it can help the child to 'forget' this uncomfortable situation. One may get the impression that the children go to the treatments only to play, but that is a wrong judgment; they do activities with toys because they feel motivated to do so, and they are seduced towards a goal. With this, activity in therapy context differs from a playful activity as long as we want to achieve a result. The main goal then is empowering the children or rehabilitating them according to the therapeutic strategies and adjust them according to what they want to do but giving a lighter disposition, making therapy recreational as well as useful.

Another objective was to understand whether there was any difference in motivation by varying the kind of toys that children with special needs play with, considering their age and knowing that children of the same age can be at different stages of development compared with the others. For example, if an eight-year-old child with special needs likes a toy target for four years old typically developing child, one should always follow the interests of the child. If children are not cognitively affected, their motivation will be the same as all children of the same age. However, this does not mean the child is physically able to play with the toy. When developing inclusive toys, one must consider the point of development where the child stands and the potential that the child must develop.

From the reviews collected, the feedback has been very positive, which gave importance to the possibility of a toy designed entirely dedicated to children with special needs. This toy is beneficial to these children as it can improve their abilities and social interaction. Besides that, some suggestions were presented to improve the toy's content based on their know-how on the

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everyday life of children with difficulties and their impairments. As there are few works in the literature related to the importance of adapting toys, the interviews with therapists about children's difficulties when playing were of utmost importance.

## Theoretical assumptions

When designing a product, in this case, a toy for children with special needs, it is essential to ensure safety and reduce risks. In the project development, it is of utmost importance to perform an ergonomic design study and a survey on the anthropometric measures to achieve a product that balances all the needs (Saptari, Kiat Ng, & Mukyi, 2013). It was, therefore, necessary to survey the anthropometric measurements of 3 to 6 years old children, having as reference the body segments involved in the various tasks (Dreyfuss, Tilley, & Wilcox, 2002) and also the support products that can be used (ex. wheelchair). This survey of the measures adopted for the evaluation of the toy has the effect of defining an adequate proportion concerning the children's anatomy.

The measures that have been considered, represented in Figures 1 and 2, were wide waist and hip with the distance between the waist down to the knee, the total length of the arm, and the length of the elbow to hand.

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*Figure 1. Anthropometric measurements of 3 years old children. Source: adapted from (Dreyfuss, Tilley, & Wilcox, 2002).*

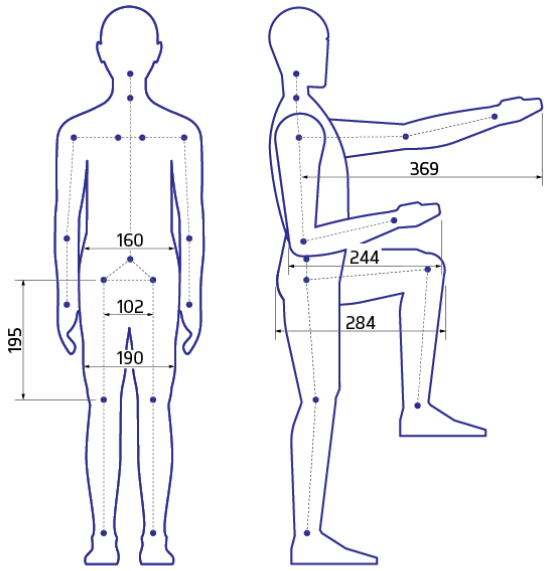
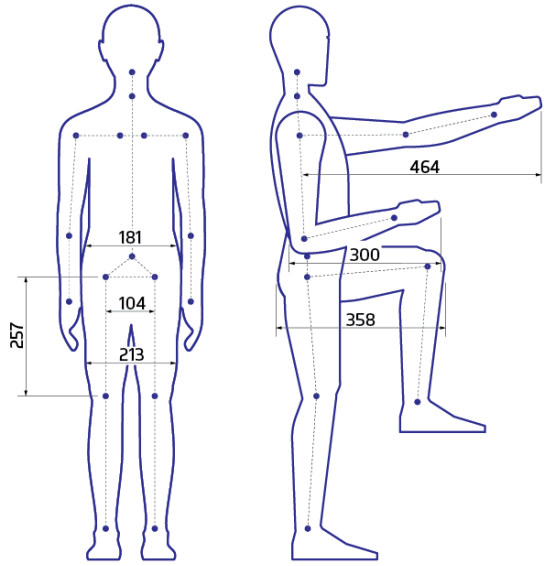



*Figure 2. Anthropometric measurements of 6 years old children. Source: adapted from (Dreyfuss, Tilley, & Wilcox, 2002).*




The distance between the child and the toy is one of the main focuses of the project, hence the importance of arm's length, since in the majority of adapted toys, the interaction is made through buttons and not with the toy itself. The reduction of the distance between the toy and the child is important for those who suffer from posture control problems and those who have a slow or too rapid coordination of the upper limbs (Abreu, Arezes, Silva,

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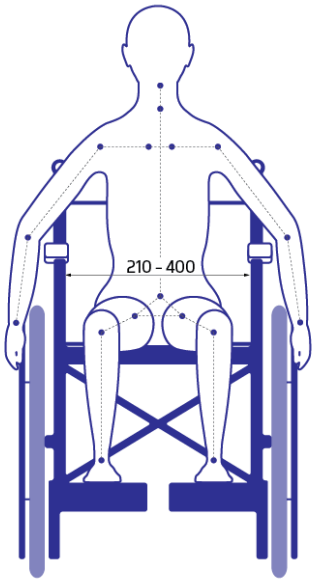
& Santos, 2015; Heide, Fock, Otten, & Stremmelaar, 2005). Also, the dimensions of the seat of a wheelchair were taken into consideration, as children's posture and ease of access to the surroundings is decisive for their comfort and concentration on the task, Figure 3.

*Figure 3. Anthropometric measures of a wheelchair seat. Source: adapted from (Dreyfuss, Tilley, & Wilcox, 2002).*




## Toy Proposal

The toys available and thought for children with special needs are, in most cases, specially designed or adapted with a switch. Some of them are outdated and the modern ones are too expensive. To overcome this gap, it is proposed in this paper an inclusive toy for children with special needs, to support and train their abilities to increase their skills, motor, social or cognitive (Brodin, 1999), to be used either for therapeutic purposes or as a simple toy.

The possibility of having a toy that is useful in training the different stages of learning while having fun, taking into account that it will require guidance when inserted into an educational activity, is of utmost importance (Brodin, 1999). The toy thus becomes a reflection, understanding the place of the children in society and showing how the child interacts (Brougère, 2004). So, one should always put the interests and motivations of the child first to be

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able to develop a toy according to the limitations and within the focus of interest of the child.

Therefore, solutions must be found for children to rediscover how to play and with what toys, instead of being deprived of play. In this context, the assisted technology arises, which has the potential to open different options in toys and games (Lane & Mistrett, 1996). Assisted technology improves the development of children by providing them with a means to be able to play, communicate, move and control their world, including adapted toys, mechanical and electrical tools, and computers (Isabelle et al., 2003).

The aim is then to design an appealing toy (various colours, textures, sizes, and sounds); easy and intuitive to play with; to be used in different positions; with adjustable height, volume, and degree of difficulty (with a variety of different actions); suitable for different ages and levels of development - a toy with a universal design and at an affordable price (Ruffino et al., 2006).

According to the professionals interviewed, table 1 summarizes the most common deficiencies in children and the associated impaired characteristics. The pathologies are related to the corresponding difficulties/disabilities, focusing particularly on generic ones. This table aims to summarize the most common impairment that may serve to identify the requirements for the proposed toy. It should be noted that all children are different from each other; two children who have the same diagnosis may not be treated the same way, they will need different approaches. Therapists/institutions are more susceptible to information about the difficulties/disabilities for which the toy is most suitable. On the other hand, for the family, and to facilitate the acquisition of the toy, the name of the impairment should be included in the toy. So, it is important to include both information in the designed toy.

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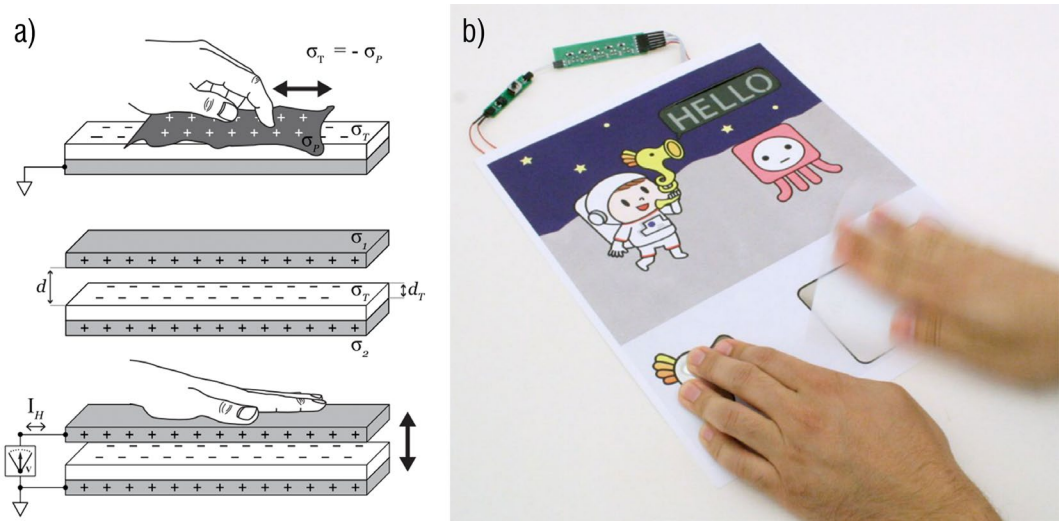
*Table 1. Most common impairments in children and their characteristics.*

| Impairment | Cerebral Palsy | Down Syndrome | Autism Spectrum Disorder | Muscular Dystrophy | Mental impairment (light) | Asperger Syndrome |
|---|---|---|---|---|---|---|
| **Visual impairment** | Apply | Apply | Does not apply | Does not apply | Does not apply | Does not apply |
| **Hearing impairment** | Apply | Apply | Does not apply | Does not apply | Does not apply | Does not apply |
| **Communication impairment** | Apply | Apply | Apply | Does not apply | Does not apply | Apply |
| **Learning impairment** | Apply | Apply | Apply | Does not apply | Apply | Does not apply |
| **Socialization impairment** | Apply | Apply | Does not apply | Does not apply | Does not apply | Apply |
| **Upper limbs inability** | Apply | Apply | Does not apply | Apply | Apply | Apply |
| **Lower limbs inability** | Apply | Apply | Does not apply | Apply | Does not apply | Apply |
| **Manual dexterity inability** | Apply | Apply | Does not apply | Apply | Does not apply | Apply |
| **Cognitive delay** | Apply | Apply | Apply | Does not apply | Apply | Does not apply |

In order to improve the interaction with the toy, electronic adaptations may be included to improve the degree of interest in the toy when compared to other more classic tools as puzzles, toys with *velcro* straps, or with large buttons (Hsieh, 2008). Considering the integration of technology into the toy, Karagozler et al. (2013) presented a new technology that captures energy from the user's interaction with materials, like paper (Karagozler, Poupyrev, Fedder, & Suzuki, 2013). This phenomenon is due to the energy field (semi-permanent charge) obtained on the surface of a thin and flexible sheet of PTFE (polytetrafluoroethylene), commonly known by its trademark - Teflon. When this sheet is rubbed with paper, the charges with opposite polarity σP and σT accumulate in the paper and PTFE surfaces due to the turboelectric effect, Figure 4.

*Figure 4. New technology that captures energy from the user's interaction with materials, (a) Technological principle; (b) Toy. Source:* (Karagozler et al., 2013).




Paper generator technology collects electricity just by applying touch (touch and/or rub). Users interact with the toy, triggering some electrical component connected to it, a LED (light-emitting diode) for example. The paper generator technology is simple to reproduce, and it is considered low-tech, offering a variety of options with the possibility to adapt the toy according to the child's interest. This technology and the use of low-cost materials bring several advantages: different forms of interaction are possible, an affordable and competitive price toy on the market, and the possibility of adaptation (Lane & Mistrett, 1996). The integration of technology in some play activities like board games, books, or puzzles for children with special needs strengthens and motivates the experience of having toys tailored to the children's needs, which contains various interactivities and allows them a first approach to the technology.

The application of the technology proposed by Karagozler et al. (2013) can offer a wider variety of activities and interactivities making the act of playing more appealing, hence it provides a higher level of involvement.

The toy is intended for 3 to 6 years old children since it is in this period that changes in children are more significant and that they begin to learn from models that surround them, to imitate adult behaviour, creating the need to relate to the world through the act of playing. The children who will be able

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to enjoy and play with the toy are all children with no severe motor and cognitive disabilities. Children who have physical disabilities such as little mobility on upper members, with small or no mobility on lower members, blind and deaf will be able to play with the toy. And those who have cognitive and social disabilities, not severe, also will enjoy the toy - as the objective of the toy is to develop different games that will have a focus on specific disabilities and have different levels going against the necessities of a child in the same base.

The activities present in the proposed toy have different levels of difficulty to cover in full the age groups, designing different forms of interaction and always trying to arouse interest in the child and promote a progressive development. The different levels will be presented with a difficulty grade. The levels, for example, can start with simple geometric figures fitting, followed by an association of primary colours, and may end with the activity of a word association with their respective images. The toy presents the possibilities of different activities, using various multi-sensory resources (lights, sounds, movement, different colours, contrasts, and textures) activated by the child. The ability to continuously create a changing toy-child interaction allows the toy to captivate the child's attention and allows the child to be constantly interacting through the choices he/she makes.

One of the problems observed and reported in the interview context - the inability of children with mobility restrictions to handle the toys - justified the need to develop a way to grab the toy in different situations. As a solution, it was developed a handle, Figure 5, (“arms”) to be able to fix it and hold to different places (tables, car front seat, the child's own body), which may also be removed when this is not accepted by the child, when the child has finished playing or if it is not necessaire. With this fixing element, it is possible to have a close relationship between the child and the toy, taking advantage of all that the toy may offer without interruptions in playing or limitations in positions that could exist. There is also the possibility/need to have removable parts in the toy, so they can be washed. As an example, the handle is in contact with various surfaces, Figure 5. With the presence of different activities, the child is the active participant, and it is also encouraged by the toy to interact with other children to get the full enjoyment of an activity in

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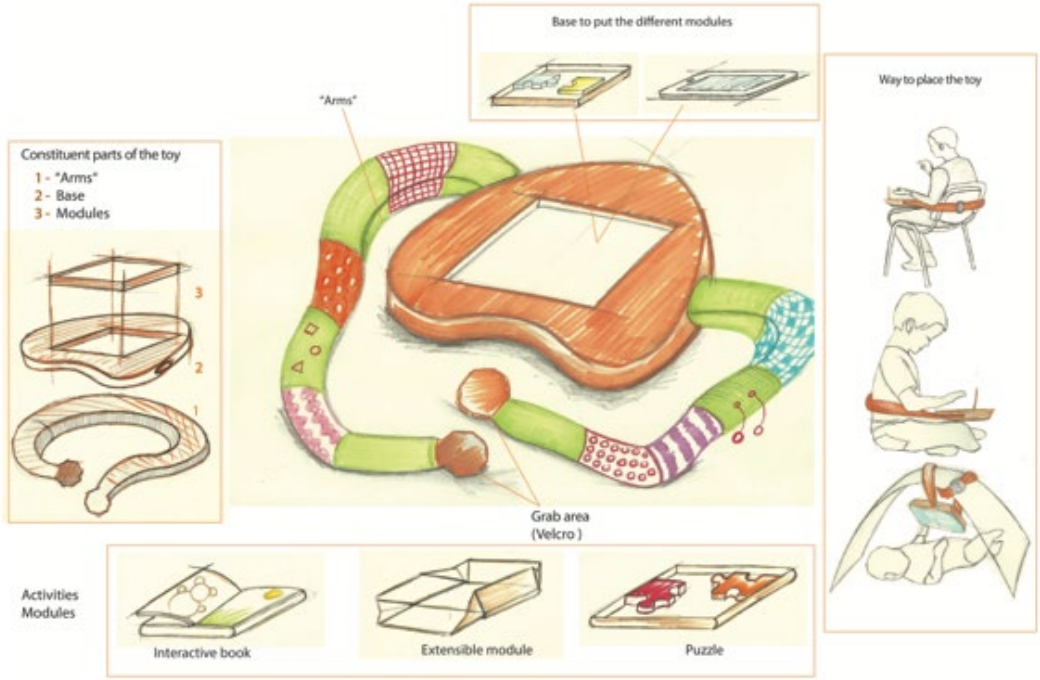
which is included to acquire social skills. The toy can also be used in the context of therapy, combined with the therapist's wants to establish the child's interaction with the toy and the chosen activity.

*Figure 5. Proposed Toy handle. Source:*(Ferreira, Matos, Soares, & Carvalho, 2017).




With the purpose that the toy can reach a higher number of children, depending on their impairment, and considering the interviews, it was decided to make the toy modular, including different activities characterized by the table, which fit into the base structure of the toy. So, the toy will have several activities suitable for different deficits and stimulations. The toy can thus provide the child to play alone, as well as in a social and cooperative approach. When the toy is inserted in the context of therapy, predefined parameters must be defined and registered to compare the evolution of the child from the first interaction with the toy to the following interventions.

It is worth highlighting the need for usability testing with children accompanied by their therapists and/or parents to validate the concept and the proposed toy. The tests will be more of notetaking and questions to the persons accompanying the children.

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## Toy Prototype

The proposed toy for children with disabilities, "HugMe" first prototype, shown in Figure 6, tries to respect the main requirements a toy must have: to be appealing, with different colours, with different textures, to be intuitive, to be used in different positions and environments, adjustable both in volume and in the difficulty level of activities, to be used in different ages and/or with different levels of cognitive development, and with an affordable value comparing to other toys (Directiva 2009/48/CE, 2009).

*Figure 6. "HugMe" first prototype.*


Throughout the toy development, the professionals who answered the questionnaire had always been present and indicated their point of view, also giving some improvement suggestions. They gave pieces of advice about the shape, the dimensions, the materials that could be used to stimulate the children, among others. "HugMe" toy has a 3-part structure, in which each component has a specific function. The "base" (Figure 7) is the main structure and the piece which supports the other two. Its components are a pillowed body with an inclination necessary for the child to remain in the most correct posture. It considers the possible motor difficulties of the child, being possible

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to place the toy in different configurations: on a chair, on a table, or on the floor. It is in this “base” that the activities and/or the tablet will be fitted.

*Figure 7. “HugMe” “base”.*

The arm, Figure 8.a is attached to the rear part of the “base” and has different textures and fine movement activities along its body. It is an extra element for stimuli. Consequently, the toy is always closer to the child, which is not the case with most adapted toys. The “arms” are fitted simply, their extremities are made of *velcro* and their length is malleable, making them easy to fit. The activities piece Figure 8.b are a key piece that has the possibility of fitting different modules with diverse activities designed for the different needs of the children. Also, it allows the simple exchange between activities. It also has a design that enables the fitting of a tablet, which increases the number of activities and interaction potential the child may have with the toy.

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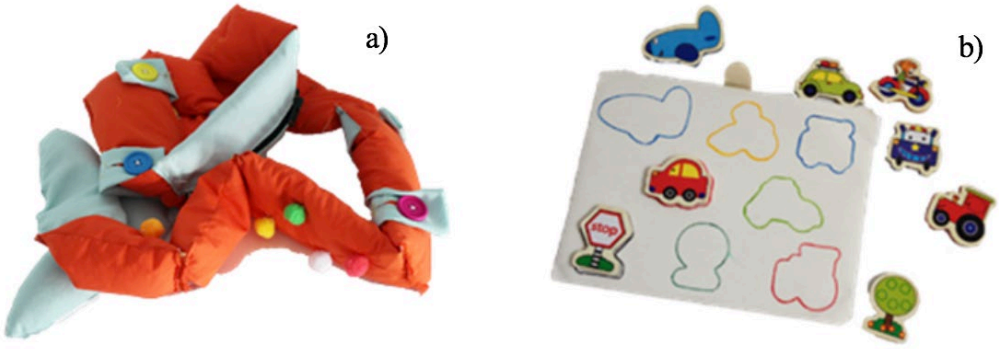
*Figure 8. HugMe (a) Arms; (b) Activity. Source: authors' photograph.*




"HugMe" can be used in different positions adapted to the child's daily posture, both in the most comfortable or in any posture correction context in a therapy session. Thus, it can be used on the floor, on a table, or in the wheelchair due to the malleable "arm" that is adaptable to multiple scenarios and can be easily removed, if necessary.

The toy hygiene requirements were also considered, which is why all the toy parts that the child can touch can be washed and disinfected. This allows for the use of the toy by different children, in an institution, for example. The choice of the materials and colours used for the prototype were chosen to be appealing to the children in the usability tests. One of the objectives of the toy is to be inclusive and personalized where the user can choose the colours, the activities, and the stimulus.

## Usability tests

HugMe prototype was tested to validate the conceptual idea of the toy as well as the proposed functions and their effectiveness. The therapists carried out the usability tests in three different associations: APAC (in Portuguese "Associação de Pais e Amigos de Crianças"), APPC (in Portuguese "Associação do Porto de Paralisia Cerebral") and 7SENSES, Figure 9, in the context of therapy sessions. The informed consents, from the therapists and the parents of the children, were obtained prior to the tests.

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*Figure 9. HugMe prototype usability tests.*

Some guidelines to test "HugMe" functionalities were introduced:

- To leave the child interact freely with the toy; to register the first impact;
- To leave the child interact with the activity:
    - Game;
    - Tablet;
- To place the grasped toy;
    - To the body of the child;
    - To the chair/table.

Twenty-five tests were carried out in children between 3 and 6 years of age, with 4 elements that do not fit the stipulated age group, to study the possible needs of widening the age group for the toy. The child's impairments were autism, cerebral paralysis (affected motor part), DiGeorge syndrome, left hemiparesis, global development delay and sensorial integration dysfunction.

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While performing the tests, there was not any distinction, neither on gender nor in the child's impairment.

After the test, the therapist of the children fulfilled a questionnaire. The questionnaire's objective was to collect information at the level of effectiveness, efficiency, and satisfaction within the presented toy to the children and their careers (therapeutic, parents). A Likert scale: Full agree-5; Agree-4; Neutral-3; Disagree-2; Full disagree-1 was considered for the analysis.

The results obtained indicate that 68% fully agree that the children felt comfortable with the toy and only 4% of the children did not feel comfortable. Regarding the proposed children's age the toy should be applied, 84% considered that the toy applies properly to different age groups. Moreover, the need to understand if the toy has some level of complexity was also considered, where 52% consider that it has no complexity, against 8% who consider that it has. It was also verified if the toy frightened the children, where 76% considered that it does not and only 8% agreed that the children were scared. In a more structural aspect of the toy, it was verified if the dimensions are the most appropriate, especially considering that the toy encloses different age groups consisting of different sizes of children. Regarding the size of the toy base, 44% fully agreed and 28% agreed that the dimension is well adjusted.

In the activity of placing a tablet in the toy, 64% fully agreed and 16% agreed that it is an asset. Comparing the interest between the tablet and the traditional game, 36% maintained their neutral response as the interest paid by the children with the tablet, while the traditional game received more interest, getting 44% and 20%, respectively, to fully agree.

Finally, considering the length of "arms" of the toy, 46% agreed that it was appropriate. Furthermore, considering the textures of the "arms" of the toy, 46% disagreed that the children felt stimulated with textures. However, when questioned about if fixing the toy is simple, 52% fully agreed and 28% agreed regarding the easiness of fixing the toy. After a brief and preliminary analysis, one can see that some points should be improved and retested. At the moment, the textures along the arms are within the fabric which will be more

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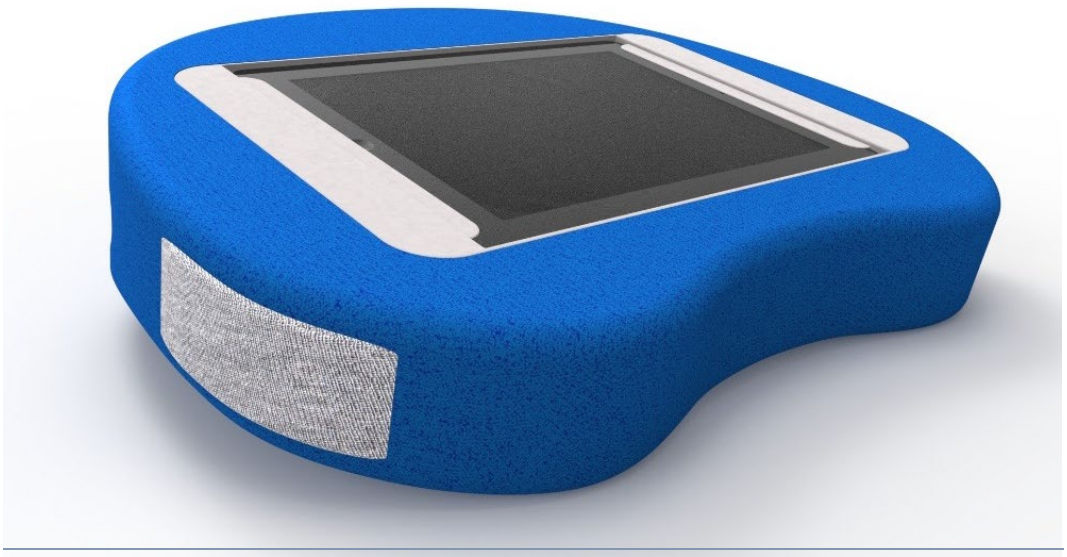
effective if placed on the outside. Moreover, it should be pursued to even get a more suitable size to the base of the toy so that it can adapt even better to all children.

## “HugMe” improvements

As a result of the usability tests, some improvements were performed on “HugMe” toy. Thus the “base” (Figure 10) and some parts in the "base" were changed, in particular the way the arms were fixed and the system for placing the activities and/or tablet.

*Figure 10. “HugMe” “base” improved prototype.*

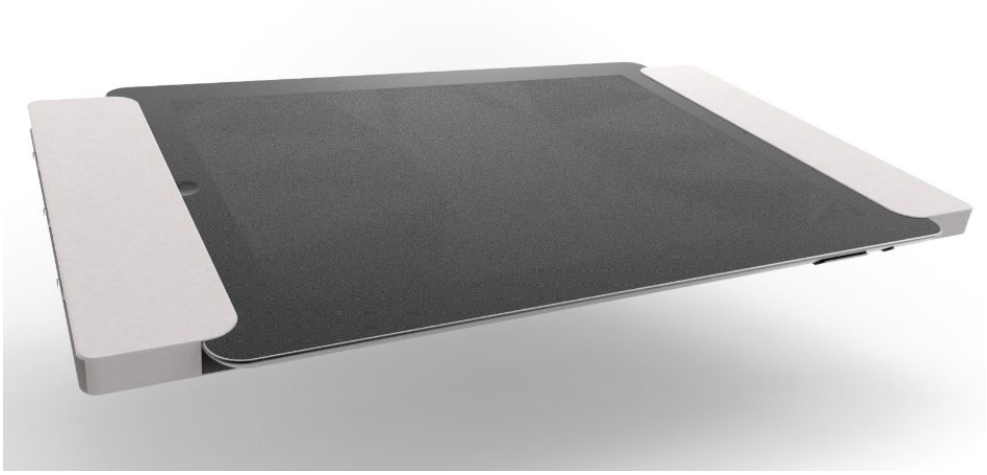


The changes made to the "arms" have to do with the fact that they are not well-positioned for the child's comfort when they were around. So, the arms started to be placed inside the base and the attachment also becomes the base itself if placed around the child, Figure 11.

*Figure 11. "HugMe" "arms" – improved prototype.*

The system for placing the activities or tablet had previously a fixed measure. It was reconsidered to offer more flexibility in the dimensional requirement of the equipment, allowing now to place tablets and activities with different sizes due to an integrated system of springs that adjust depending on the size of the activity and/or tablet (Figure 12).

*Figure 12. HugMe System for tablet and activities – improved prototype.*



## Final remarks

Usually, impaired children may play with adapted toys which are not designed for them from scratch. Toys designed for typically developing children are adapted for children with disabilities, and sometimes at very high prices. We consider that there is a need for designing, developing, and constructing a toy that includes particular functionalities and stimulus, which may serve to several child impairments.

A proposal for an inclusive toy entitled “HugMe” was presented to simplify the act of playing for children with specific needs. The design makes it possible to achieve a change in the way children play without the common obstacles they usually feel, showing that they are equally capable and possess the same abilities and opportunities that other children have for granted. With these principles, it is possible to take different approaches, with projects mainly focused on increasing the accessibility of play for all children and in creating new opportunities for them. One can thus say that this toy distances from the toys available in the market, being an advantage and an asset. It was designed from the first stage thinking in the accessibility of children with special needs, making it an inclusive toy.

The goal of this study was to ascertain the relevance of the proposed inclusive toy “HugMe”. The results of the usability tests allowed us to conclude that the first version of the toy “HugMe” is worth considering, and some points for improvements were highlighted. At this stage, these improvements were performed only in 3D drawing, which will be needed to further the development of a new prototype. “HugMe” base and arms were improved accordingly to the therapists' and parents’ suggestions. Further tests, in therapeutically and entertainment sessions, are needed to test the new prototype.

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# THE PAST, PRESENT, AND FUTURE OF ACCESSIBLE TOURISM RESEARCH: A BIBLIOMETRIC ANALYSIS USING THE SCOPUS DATABASE

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***Abstract*:** At present, it is estimated that there are more than 1 billion people with some type of disability worldwide. Against this background, it is important to reconceive every life sphere and activity to ensure the inclusion, participation and equal opportunity of people with disabilities and to promote respect for their capacities and desires as people. The tourism sector is leaving large segments of global society behind. Tourism companies need more training and guidance to address the requirements of tourists who have specific needs or require certain types of support. This study aims to analyze and map the progress in scientific research on accessible tourism. To achieve this objective, this paper presents a bibliometric analysis of scientific papers on accessible tourism published in the Scopus database between 1997 and 2021. The study used the VOSviewer and CiteSpace software to map and visualize publication trends within this field. A total of 254 articles were included, of which 95.6% were original research. These studies were published in 52 countries. Australia is among the countries with high research productivity in this field. The most productive journals are Tourism Management and Sustainability (Switzerland), and the most prominent author is Simon Darcy. The analysis of keywords allows us to continually review the opportunities that new information and communication technologies (specifically smartphones and virtual reality) offer for the future development of the accessible tourism sector.

***Keywords:*** Accessible tourism; Disability; Research trends

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## Introduction

According to the World Health Organization (WHO) (2011), around 15% of the total world population (about 1 billion people) lives with some type of disability. As a result, the WHO considers the accessibility of tourism facilities, products, and services a fundamental part of any responsible and sustainable tourism policy.

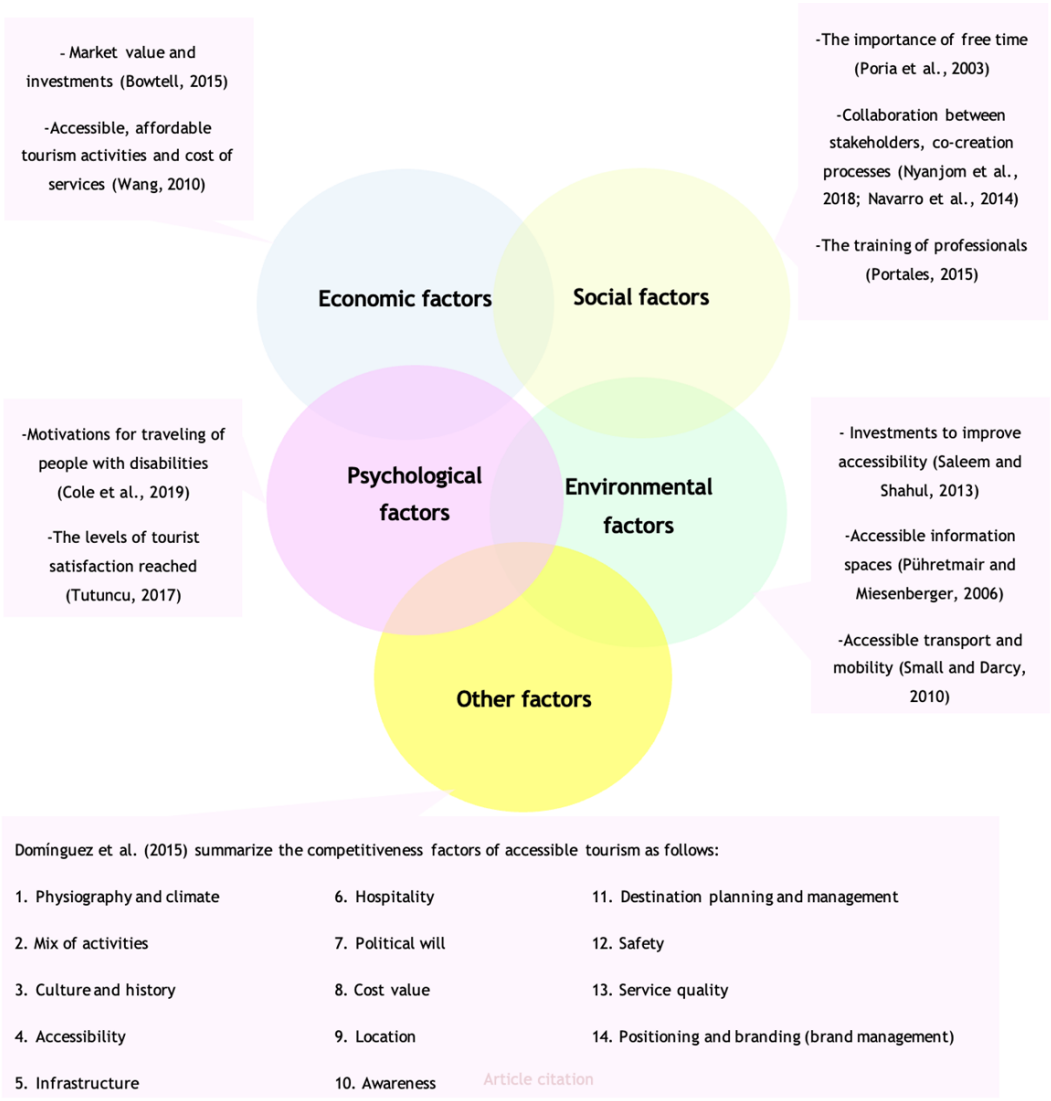
The evolution exhibited by models of disability, as well as changes in social perceptions, have driven the transformation of accessible tourist services, which are becoming increasingly diversified (Zajadacz, 2015). According to leading authors in the field, accessible tourism (AT) can be understood as:

A specific form of tourism in which collaborative processes are generated between the different stakeholders allows people with accessibility requirements to function independently, with inequity and dignity, through tourism products and services focused on universal design (Darcy and Dickson, 2009; Gillovic et al., 2018-a).

As an extension of this conception of AT, some authors began to link it with the notion of "inclusive development". Inclusive tourism, from this perspective, is understood as tourism in which marginalized groups are involved in terms of ethical production and consumption and which vulnerable and/or marginalized groups share the benefits (Scheyvens and Biddulph, 2018).

Based on the contributions of various studies, Figure 1 summarizes the factors deemed necessary for the development of high-quality AT.

*Figure 1. Some determining factors of quality accessible tourism.*




Understanding the general problems that persist concerning accessibility in tourist environments is key for ensuring the development of positive tourism experiences and devising procedural manuals allowing the tourist industry to better serve individuals with all levels of disability (Darcy, 2008). Bibliometric studies can highlight emerging trends within a research area and, in the context of AT, offer guidance on the future of the sector, as well as the mindset of visitors, service providers, planning agencies and tour operators; they can also provide insight into the current state of research in the field of AT.

Previous bibliometric analyses of AT research are available in the literature; however, they contain few studies (Tite et al., 2021); focused on very specific topics, such as “the perspectives of managers who work in hotel companies on

AT" (Akinci et., 2019), or pertain to highly specific geographical areas (Köseoglu et al., 2015).

Due to the notable increase in scientific papers within the general field of AT, it is necessary to conduct a new bibliometric study to summarize the changes in the intellectual structure of this field that have occurred over time. Therefore, this study aims to analyze and map progress in scientific research on AT by evaluating past contributions to the field, the current state of research, and possible future trends in this sector based on the literature.

## Methodology

### Search strategy

The source documents for the bibliometric analysis were obtained from the Scopus database, one of the most authoritative databases of scientific publications (Archambault et al., 2009). According to the Scopus Content Coverage Guide (2020), Scopus is the most complete database of global scientific research, especially in the fields of science, technology, medicine, social sciences, arts and humanities. Moreover, Scopus is one of the most widely used databases for almost all scientific disciplines (AlRyalat et al., 2019). Against this background, and because of the widespread use of Scopus among previous bibliometric analyses (Palomo et al., 2017; Niñerola et al., 2019), we used Scopus for our analysis of AT research, as well as research pertaining to the concept of "tourism for all". The final bibliographic search was carried out between February and April 2021.

The terms included in the search string were Medical Subjects Heading (MeSH) terms for Medline, ProQuest and EBSCO Thesaurus (Shiri et al., 2002). The main terms used in previous relevant articles were also reviewed. The final terms/concepts included in our search equation were as follows: (1) Accessible tourism; (2) Tourism for all; (3) Inclusive tourism; and (4) People with disabilities. An expert in bibliographic searches provided advice regarding how to develop an adequate search strategy to meet the objectives of this

study. Table 1 shows the full search strategy, along with the labels, operators, and filters.

*Table 1. Bibliographic search strategy*

| Database | Search strategy | Filters |
|---|---|---|
| Scopus | (ALL ("Accessible tourism") OR ALL ("Tourism for all") OR ALL ("Inclusive tourism") AND ALL ("People with disabilities")) | (EXCLUDE (DOCTYPE, "cp") OR EXCLUDE (DOCTYPE, "ch") OR EXCLUDE (DOCTYPE, "bk") OR EXCLUDE (DOCTYPE, "ed") OR EXCLUDE (DOCTYPE, "le") OR EXCLUDE (DOCTYPE, "no")) |

*Note*. The filters all relate to the exclusion criteria implemented in this study.

## Selection of study area and inclusion criteria

When carrying out the bibliometric analysis, the following considerations and inclusion criteria were applied:

1. To obtain more reliable and accurate results, only “articles” and “reviews” were considered. Therefore, the initial database search was refined according to the type of study.

2. Only articles published in the period 1997-2021 were considered, based on previous research charting the development of universal accessibility in the field of tourism.

3. Articles were not filtered according to language or the availability of free (vs paywalled) full text. Similarly, the author, institution, country and keyword variables were unfiltered, as they were used to generate the bibliometric indicators.

All data obtained via the literature search were independently verified by two investigators (C.S.H. and A.J.R.-C.) to reduce the risk of bias. More specifically, the titles and abstracts of each document were reviewed. It was unnecessary to rule out any studies during this process since they all met the inclusion/eligibility criteria. Table 2 summarizes the study inclusion criteria.

*Table 2. Criteria for including studies in the bibliometric analysis.*

| Research item | Delimitation |
|---|---|
| Database<br>5.6 | Scopus<br>4.1 |
| Type of documents<br>15.7 | Articles and Reviews<br>4.9 |
| Document content | Articles related to Universal Accessibility in the field of tourism |
| Publication date | Articles published between 1997-2021 |

## Data analysis

All of the bibliographic data were extracted from the Scopus database, including the following: (1) citations; (2) bibliographic information; (3) abstract and keywords; (4) financing details; and (5) other information. All data were exported to the software in "CSV" file format. The bibliometric techniques and software used to evaluate the research were as follows:

1. Country analysis; keyword analysis; visualization of collaboration/cooperation networks; pennant diagram of the study concept; and keyword timeline. Program: CiteSpace 5.7.R2 (64 bit; licensed under Java Runtime v.8 update 91, build 1.8.0_91-b15) (Chen et al., 2010; Chen, 2005; Chen, 2014) and Microsoft Excel 2016 (Microsoft Corp., Redmond, WA, USA).

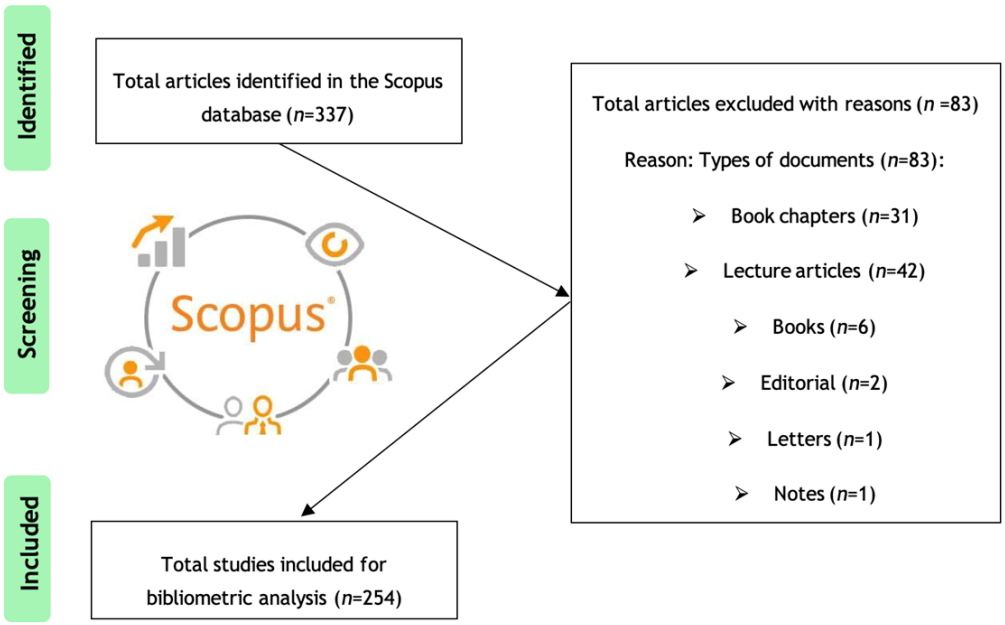
2. Author analysis; analysis of co-citations; journal analysis; and keyword analysis. These analyses yielded bibliographic association strength and cluster data. Program: VOSviewer version 1.6.15 (Drexel University, Philadelphia, PA, USA) (Van-Eck and Waltman, 2013; Van-Eck and Waltman, 2017).

# Results

## Results of the bibliographic search

The advanced search for studies in Scopus, which followed the specifications outlined in the previous sections, yielded 337 documents. Subsequently, and to avoid bias, we performed a blinded peer review of the titles and abstracts. A third expert author resolved any discrepancies arising during this process; however, no study was eliminated based on the subject matter, since all were related to AT-and tourism for all. The studies were then filtered according to document type. During this phase, 83 documents were eliminated, i.e., all book chapters (9.20%), conference articles (12.46%), books (1.78%), editorials (0.59%), letters (0.30%) and notes (0.30%). In total, 254 studies were included in the bibliometric analysis. The screening process, from the initial results to the final selection of studies for inclusion in the bibliometric analysis, is shown in the flow diagram in Figure 2.

*Figure 2. Flowchart on document retrieval and screening.*




## Results by publication type and trends in AT literature

A total of 254 studies were included in the bibliometric analysis, of which 243 were original articles (95.6%) and 11 were review articles (4.3%). Our analysis

shows how AT research volume has progressively increased over the last 24 years, from 1 article in 1997 to 52 in 2020 (2021 was not considered since it was still in progress at the time of the search). The marked increase in research since 2016 (see Figure 3) is mainly due to the increased productivity of the following authors:

- Simon Darcy, who conducted numerous studies on tourism related to social inclusion, sustainability, disability studies, sports events, and volunteer tourism (Darcy et al., 2016; Darcy et al., 2018; Darcy et al., 2020).

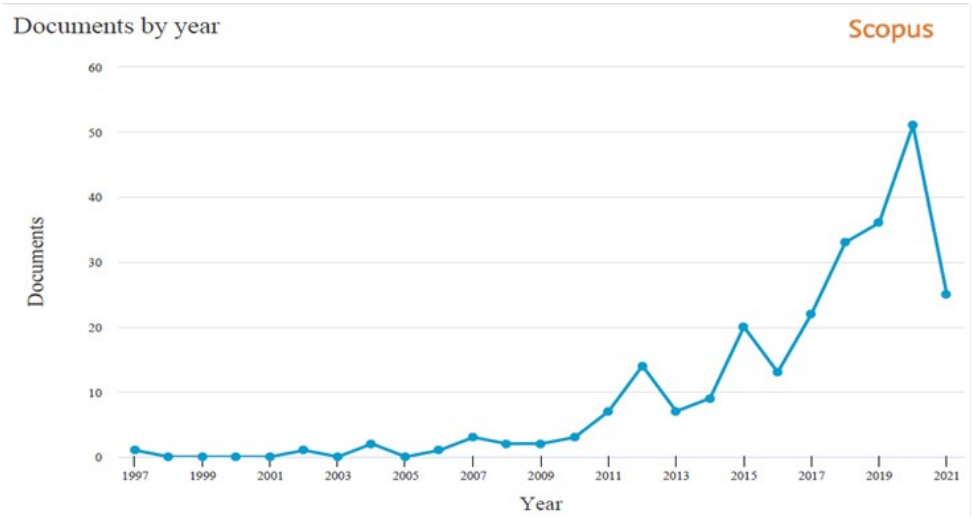
- Brielle Gillovic, who carried out studies on tourism related to AT, care, critical tourism and disability (Gillovic et al., 2018-a; Gillovic et al., 2018-b; Gillovic et al., 2020).

- Trinidad Domínguez, who carried out studies on disability, the elderly and tourist accommodation (Domínguez-Vila et al., 2016; Losada et al., 2017), and the accessibility of web spaces (Domínguez-Vila et al., 2017; Domínguez-Vila et al., 2018).

Starting in 2015, measures were taken to regulate the accessibility of tourism, i.e., to ensure that services are adapted to meet the needs of all people and thus promote AT. These measures include the publication of the *Manual on Accessible Tourism for All - Public-Private Partnerships and Good Practices* by the World Tourism Organization (UNWTO), which served as a basis and guide for numerous subsequent studies.

For several years, experts from more than 100 countries have been working on ISO standard 21902: *Tourism and related services* - AT *for all* - *Requirements and recommendations*, under the direction of the ONCE Foundation, World Tourism Organization (UNWTO) and Spanish Association for Standardization, UNE. This ISO will stipulate the standards that tourism providers must meet for their services to be accessible to all and provide guidance on how to create, design and present information in an accessible way. Other issues to be covered by the standard include accommodation, transportation and restaurants.

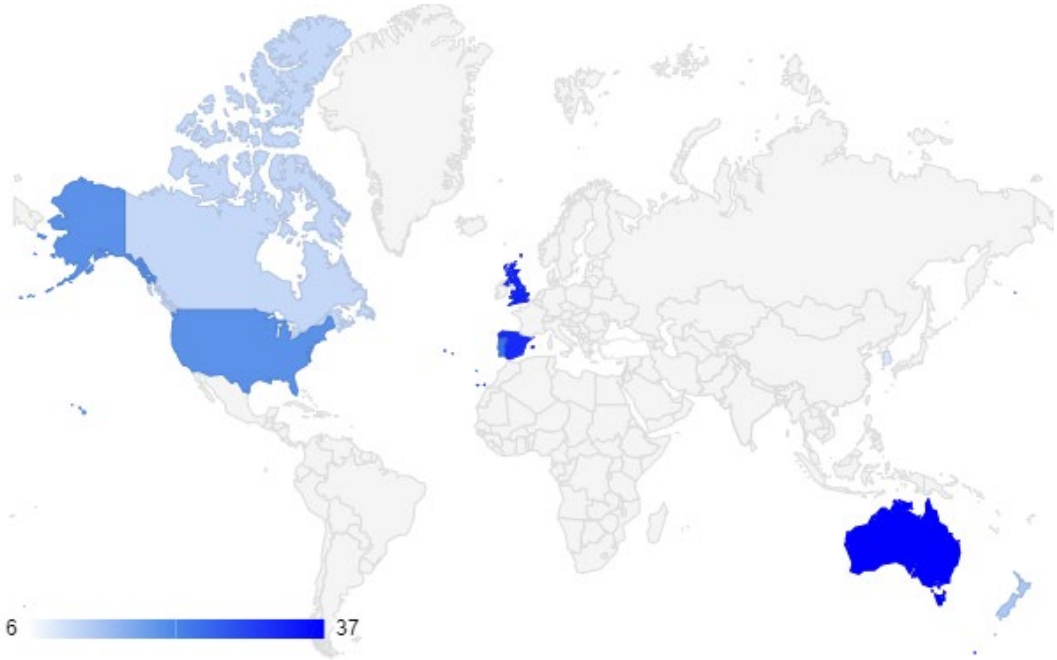
*Figure 3. Total of studies published between the years 1997-2021.*




## Analysis of countries and institutions

The contribution of individual countries to AT research is illustrated in Figure 4. Authors from 52 countries have published publications on AT. The 10 most productive countries, in order, have been Australia (n = 37 studies; 14.57%), the United Kingdom (n = 33; 12.99%), Spain (n = 32; 12.60%), Portugal (n = 24; 9.45%), the United States (n = 20; 7.87%) , Canada (n = 13; 5.12%), The Netherlands (n = 13; 5.12%), Italy (12; 4.72), South Korea (9; 3.54%), and Ghana (7; 2.76%).

*Figure 4. Worldwide geographical distribution of the research results in AT.*



*Note*. The world map of the productivity of publications by countries within the field of AT can be interpreted by observing the indicator located in the lower-left (productivity, in the countries where at least one work was published, increases from light blue to dark blue, based on the number of publications).

Bibliometric association strength was calculated using VOSviewer version 1.6.15. The bibliometric association strength is based on the strength of the links for a given element concerning other elements, with the number of documents and citation counts taken into account (Eck and Waltman, 2009). The three countries with the highest bibliometric association strength, that is, the most productive, cited, and collaborative countries, were Australia, the United Kingdom and Spain 32 (see Table 3). Figure 5 clearly shows the relationships among the most productive countries.

Finally, Table 4 shows the most productive institutions within the field of AT research. The University of Technology Sydney, UTS Business School (n = 42 studies; 16.54%) is the top-ranked institution, followed by the University of Aveiro (n = 13; 5.12%) and Auckland University of Technology (n = 9; 3.54%).

*Table 3. The 10 most influential countries*

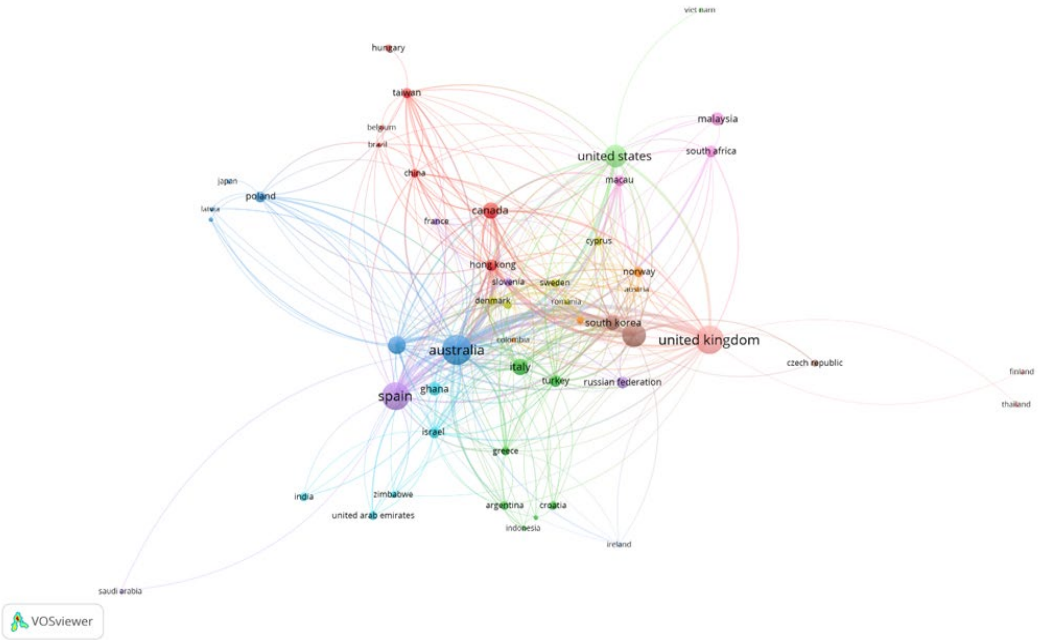
| Ranking | Country | Documents (%) *N*=254 | Citation count | Total link strength |
|---|---|---|---|---|
| 1st | Australia | 37 (14.57%) | 939 | 579 |
| 2nd | United Kingdom | 33 (12.99%) | 290 | 290 |
| 3rd | Spain | 32 (12.60%) | 229 | 229 |
| 4th | Portugal | 24 (9.45%) | 208 | 208 |
| 5th | United States | 20 (7.87%) | 163 | 163 |
| 6th | New Zealand | 13 (5.12%) | 140 | 140 |
| 7th | Hong Kong | 6 (2.36%) | 138 | 138 |
| 8th | South Korea | 9 (3.54%) | 123 | 123 |
| 9th | Canada | 11 (5.12%) | 111 | 111 |
| 10th | Turkey | 6 (2.36%) | 81 | 81 |

*Tabla 4. The 10 mostinfluential institutions*

| Ranking | Institutions | Documents (%) *N*=254 |
|---|---|---|
| 1st | University of Technology Sydney. UTS Business School. | 42 (16.54%) |
| 2nd | Universidade de Aveiro | 13 (5.12%) |
| 3rd | Auckland University of Technology | 9 (3.54%) |
| 4th | Universidade de Vigo | 8 (3.15%) |
| 5th | Universidad de Malaga | 7 (2.76%) |
| 6th | Bournemouth University | 7 (2.76%) |
| 7th | Indiana University Bloomington | 6 (2.36%) |
| 8th | The University of Queensland | 6 (2.36%) |
| 9th | University of Waikato | 5 (1.97%) |
| 10th | Universidade do Algarve | 5 (1.97%) |

*Note*. Tables 3 and 4 represent different rankings. The interpretation of the same must be made separately. In most cases, there is no direct correspondence between the countries and the location of the institutions.

*Figure 5. Cluster view of the most active countries in the field of AT.*

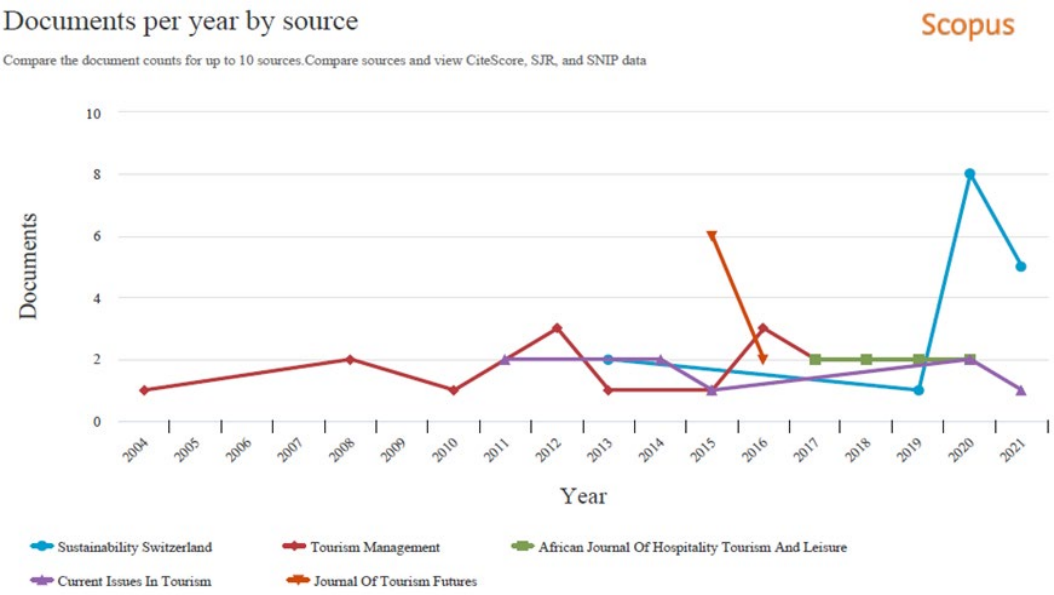


*Note*. Each colour in the figure represents groups of cooperative relationships between countries. The size of the clusters (circles) is linked to greater or lesser cooperation between a country and the other countries.

## Journal analysis

The 254 articles were published in 120 academic journals. Figure 6 shows the yearly trends in publications in the five leading journals worldwide in terms of AT research. Sustainability Switzerland is the top-ranked journal, with eight AT studies published in 2020.

*Figure 6. Number of documents by year and source.*




According to the analysis of bibliometric association strength, the journals with the most collaborations are Tourism Management (n = 16 collaborative studies; 6.30%, Sustainability (Switzerland) (n = 15; 5.91%) and the Journal of Hospitality and Tourism Management (n = 6; 2.36%) (see Table 5).

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*Table 5. The 10 most influential journals in the field of AT research.*

| Ranking | Journal | Documents (%) *N*=254 | Citation count | Total link strength |
|---|---|---|---|---|
| 1st | Tourism Management | 16 (6.30%) | 2232 | 315 |
| 2nd | Sustainability (Switzerland) | 15 (5.91%) | 44 | 129 |
| 3rd | Journal of Hospitality and Tourism Management | 6 (2.36%) | 154 | 112 |
| 4th | Journal of Tourism Futures | 8 (3.15%) | 130 | 89 |
| 5th | International Journal of Hospitality Management | 6 (2.36%) | 102 | 79 |
| 6th | Journal of Sustainable Tourism | 5 (1.97%) | 94 | 75 |
| 7th | Current Issues in Tourism | 7 (2.76%) | 363 | 59 |
| 8th | International Journal of Tourism Research | 3 (1.18%) | 142 | 57 |
| 9th | Annals of Tourism Research | 6 (2.36%) | 110 | 56 |
| 10 th | Tourism Management Perspectives | 2 (0.79%) | 37 | 56 |

Similarly, VOSviewer version 1.6.15 was used to visualize the leading journals in the field of AT. Notably, although journals such as Tourism Management have made the largest contribution to the field and exhibit the most links/relationships, the overlay display indicates that they were most productive around 2014. More recently (approximately since the end of 2019), journals such as Sustainability (Switzerland) have exhibited greater productivity (albeit not over the entire study period) and more links with other journals (see Figure 7).

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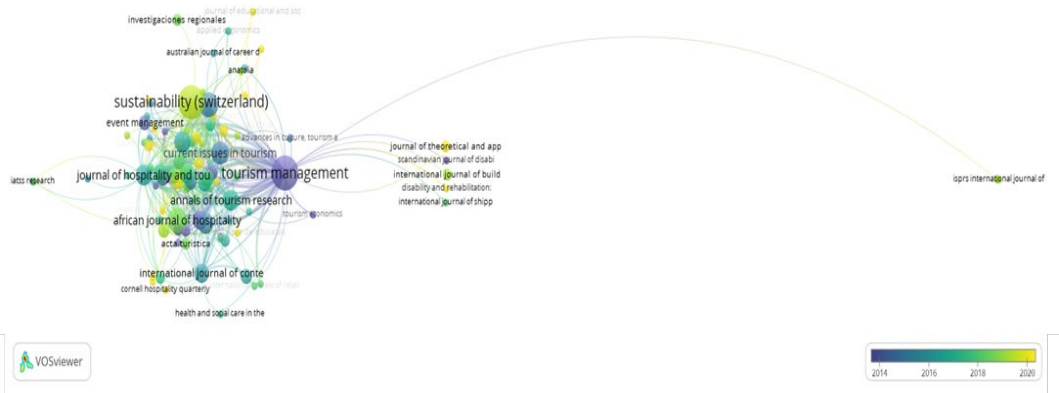
*Figure 7. Cluster view of the most active sources in the AT field.*




## Analysis of authors and co-citation networks

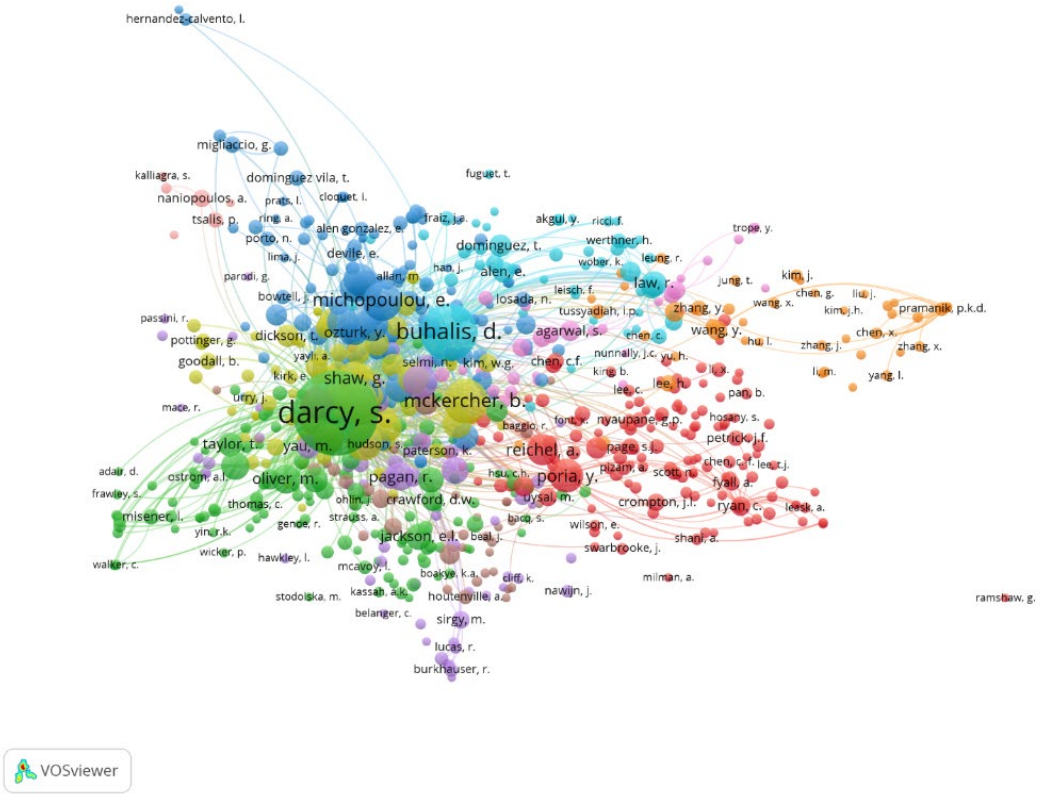
A total of 492 authors were involved in the 254 retrieved articles. The top 10 most influential authors are shown in Table 6. Again, both the number of citations and bibliometric association strength, which relates to the number of studies published by a given author and the citation count of those articles, are shown. As for the figures previously presented, the VOSviewer version 1.6.15 selection parameters included a minimum of one document per author (i.e., the author must have at least one published article), with no filter applied to the minimum number of citations (i.e., any study by the author is eligible, even if it has not been cited). The best-represented authors were Darcy S. (n = 1061 articles), Eusébio C. (n = 370) and Kastenholz E. (n = 108).

A total of 16,085 authors were co-cited by the 254 studies included in this bibliometric analysis (see Table 6). Due to the high rates of co-citations, only authors with a minimum of five citations are shown to improve the clarity of the figure. A total of 733 authors were thus represented. The three authors with the highest bibliometric association strength were Darcy S. (n = 57,068 citations), Buhalis D. (n = 24,951) and Mckercher B. (n = 14389; see Table 5 and Figure 8).

*Table 6. The ten most influential authors and most co-cited authors in the field of AT.*

| Ranking | Author | Documents (%) *N*=254 | Citation count | Total link strength | Co-cited authors | Citation count | Total link strength |
|---|---|---|---|---|---|---|---|
| 1st | Darcy S. | 24 (9.45%) | 751 | 1061 | Darcy S. | 939 | 57068 |
| 2nd | Eusébio C. | 9 (3.54%) | 97 | 370 | Buhalis D. | 363 | 24951 |
| 3rd | Kastenholz E. | 4 (1.57%) | 108 | 276 | Mckercher B. | 203 | 14389 |
| 4th | Dickson T.J. | 5 (1.97%) | 162 | 234 | Michopoulou E. | 144 | 9660 |
| 5th | Figueiredo E. | 2 (0.79%) | 89 | 208 | Packer T. | 137 | 8172 |
| 6th | McIntosh A. | 6 (2.36%) | 56 | 195 | Pegg S. | 123 | 8151 |
| 7th | Mckercher B. | 3 (1.18%) | 92 | 192 | Miller G. | 112 | 7634 |
| 8th | Pegg S. | 3 (1.18%) | 135 | 177 | Poria Y. | 107 | 7526 |
| 9th | Gillovic B. | 3 (1.18%) | 43 | 161 | Small J. | 103 | 7345 |
| 10 th | Buhalis D. | 3 (1.18%) | 1579 | 155 | Kastenholz E. | 95 | 7101 |

*Figure 8. Cluster view of the authors with the highest co-citations in the field of AT.*




*Note*. Each colour represents co-citation networks between authors. The size of the nodes (circles) is related to higher or lower levels of co-citations per author.

## Keyword co-occurrence network

Keyword analysis has been widely used to understand the knowledge structure of specific research domains. These analyses are considered vital within bibliometric studies (Che and Xiao, 2016). In this study, using VOSviewer version 1.6.15, an automatic network measure based on centrality was applied to select highly similar keywords. The program was used to carry out a co-occurrence analysis of all keywords.

The program detected a total of 1158 keywords among the 254 articles included in this bibliometric analysis. For clarity of the generated graph, each keyword was required to appear at least twice; 267 keywords met this threshold.

The keyword co-occurrence network map clearly showed past, present and future trends in the literature on AT. The top 10 terms, i.e., those appearing

with the most co-occurrence links, are as follows (in descending order): Disability (n = 115); Accessible tourism (n = 73); Accessibility (n = 61); Tourism (n = 56); People with disabilities (n = 30); Tourism destination (n = 20); Travel behavior (n = 17); Tourism marketing (n = 16); Tourism development (n = 16); and Tourism management (n = 15) (see Figure 9, Part 1). Part 2 of Figure 9 shows the trends over time of the aforementioned keywords.

We can see how AT research is currently prioritizing ecotourism, inclusive tourism and virtual reality. Research is also largely focused on the visions of the various stakeholders within the inclusive tourism sector. These trends also indicate the likely future directions of AT research. We can also see how concepts related exclusively to disability have been diluted; AT and tourism for all have promoted the view that everyone, regardless of disability status, should be able to enjoy tourism.

*Figure 9. Cluster view of keywords.*

*Figure 9. Part 1. Cluster view of the most frequent keywords in AT.*

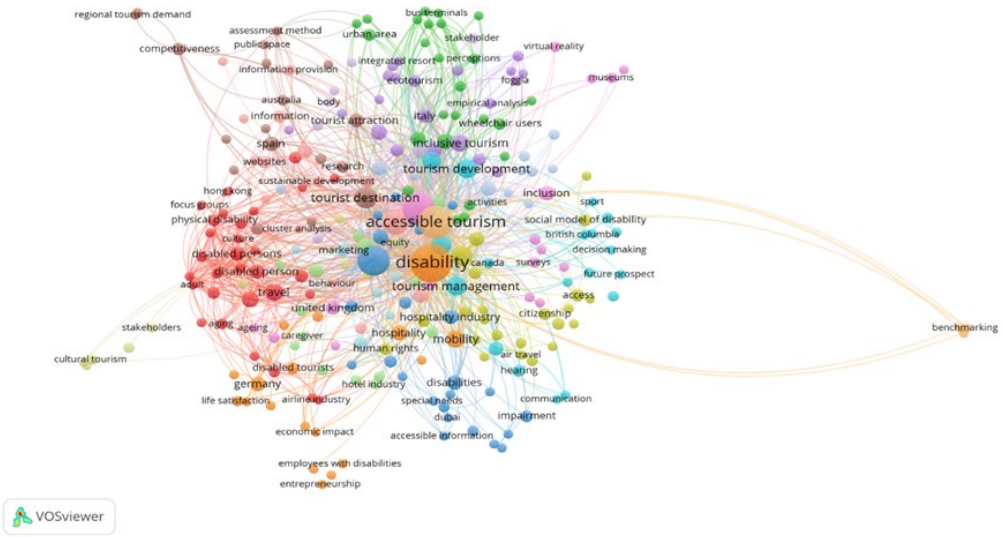
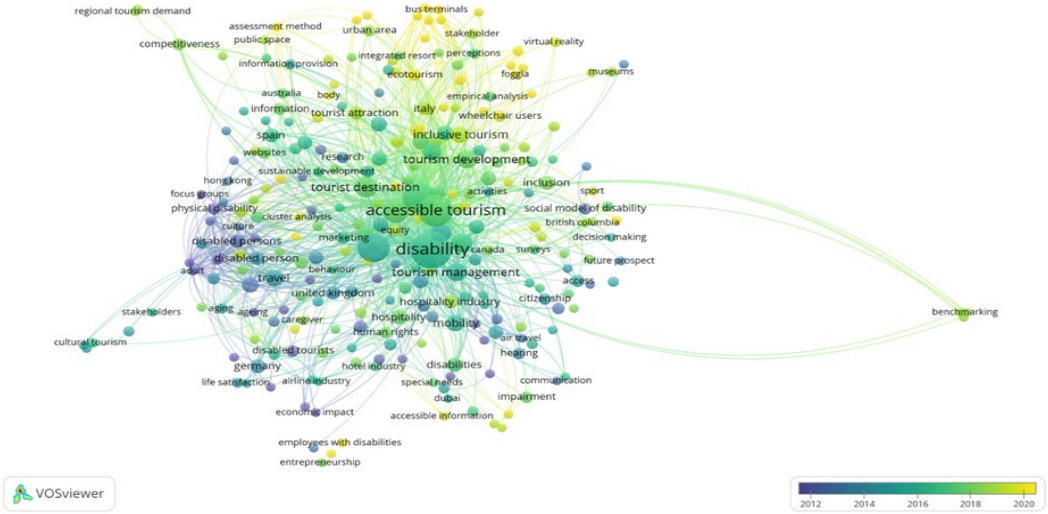
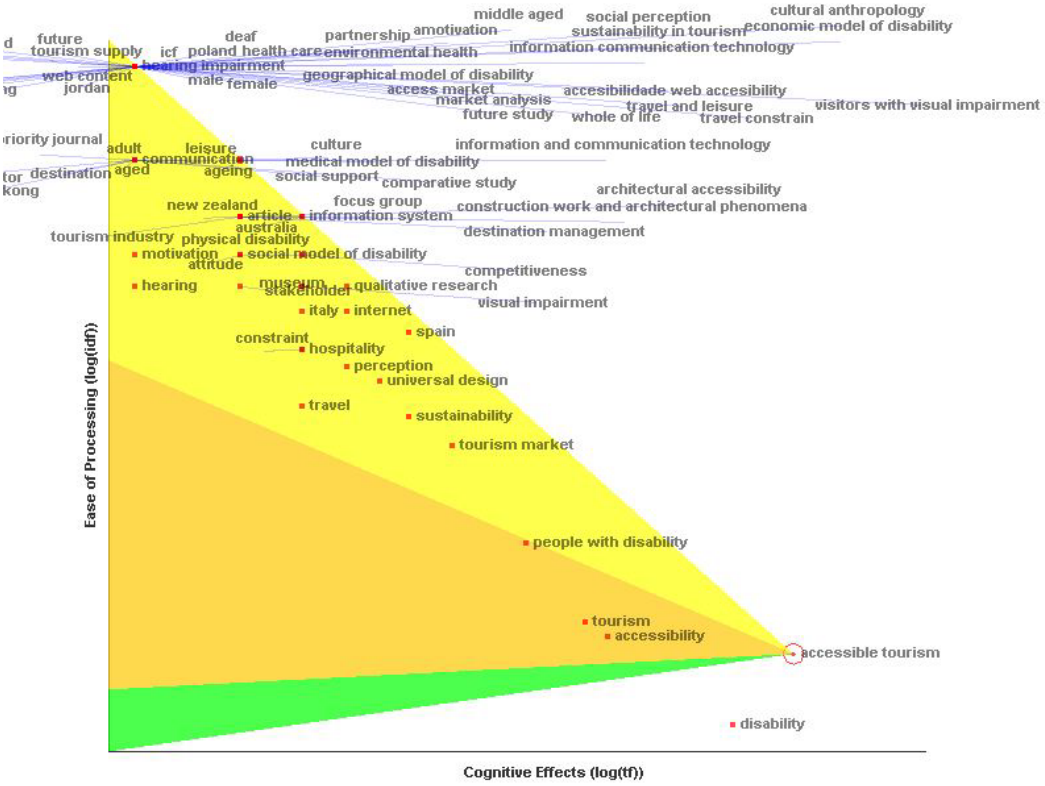


*Figure 9. Part 2. Cluster view of keywords based on the time of appearance (progression by years of literature).*




A more detailed analysis was performed using CiteSpace 5.7.R2 (64 bit) software, given the importance of keyword analysis for understanding research productivity. Flag diagrams provide information about keywords directly connected to nodes; keywords in closer proximity in the graph are more frequently correlated in the studies from which they derive. It can be seen that AT, i.e., the second most frequent concept/keyword in the 254 articles and the one most closely aligned with the objectives of this bibliometric analysis, has co-occurrence links (a relationship of two or more terms within a text unit) with (in descending order) Disability, Tourism, Accessibility, People with disabilities, Tourism marketing, Sustainability, Travel, Universal Design and Perception (see Figure 10).

*Figure 10. Pennant diagram of concepts related to the term Accessible Tourism.*




Finally, a keyword timeline was made; this is useful for analyzing groups of words that appear interconnected among studies. In addition to grouping related terms, CiteSpace 5.7.R2 (64 bit) can present the evolution of the literature over time. Table 7 shows all 20 concept groupings resulting from the keyword analysis of the 254 articles. Figure 11 shows the evolution of terminology within the field and the existing connections between the different groupings. As of 2020, concepts of particular interest included “Smartphones”, “Special assistance”, “Differentiation strategy”, and “Information marketing”; these will be discussed later in terms of their contributions to AT.

*Table 7. Summary of the 20 groups in AT research in the period 1997-2021.*

| Ranking | Concepts that form the grouping |
|---|---|
| #0 | Social; life; quality; policy; benefic health; mental; public |
| #1 | Market; information marketing; communication; technology travel; motivations; profitability; practice |
| #2 | Travel; internet; wcag; medical; education qualitative; care; caregiver; canada; medical |
| #3 | Human; architectural; person; disabled; application aged; adult; environment; environmental |
| #4 | Approach; perception; people; mobility; transport destination; stakeholder; development; families |
| #5 | Universal design; area hospitality; delivery; quality; stereotyping; operation |
| #6 | Tourist; stakeholder; destination; approach; reality planning; network; attraction; urban; method |
| #7 | Travel; willingness; choice; experiment; product management; blind; dog; familiar; sensory |
| #8 | Sport; british; columbia; sports; infrastructure disability; orientation; normality; medical; human |
| #9 | Competitiveness; human; policy; right; brazil attraction; research; management; visitor; spain |

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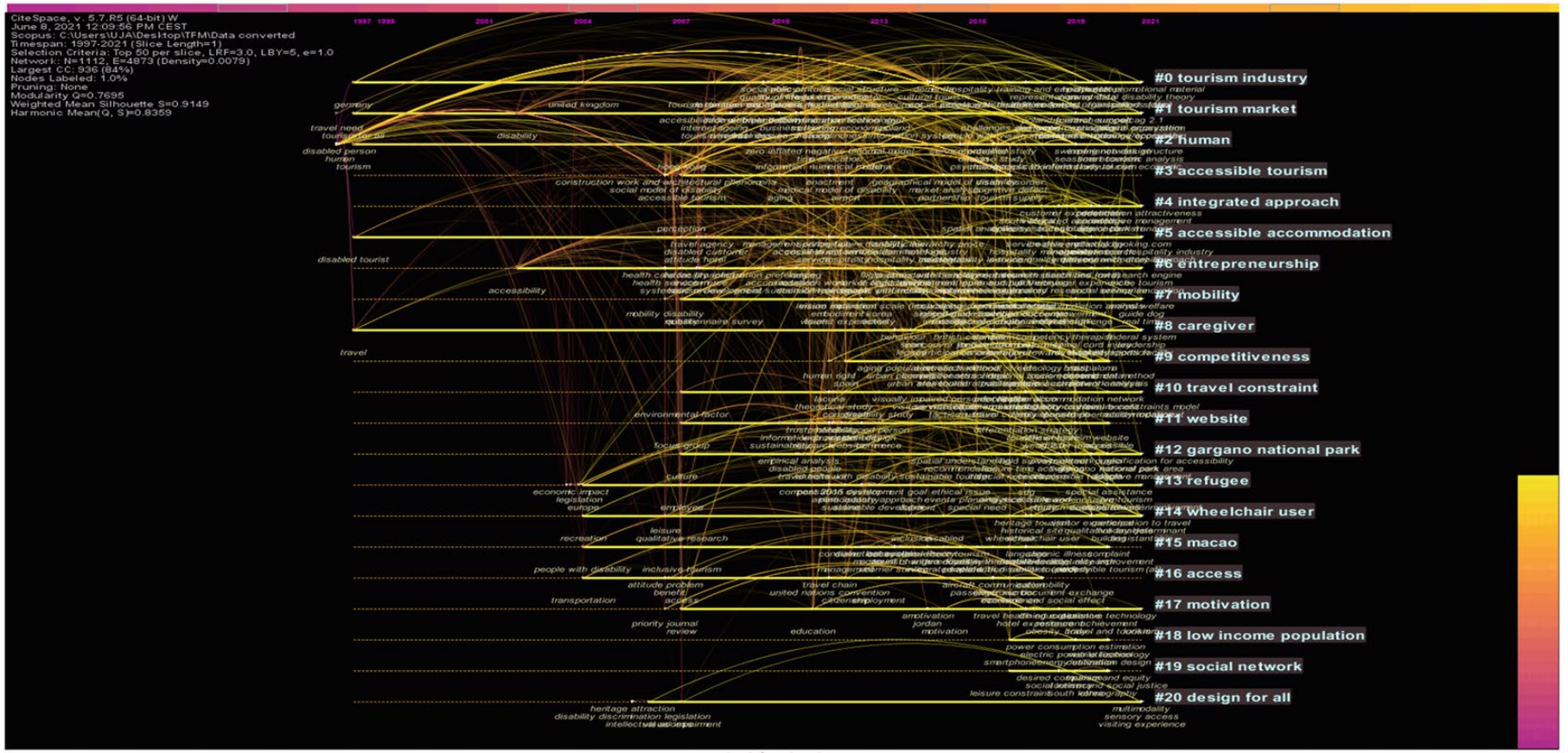
| Ranking | Concepts that form the grouping |
|---|---|
| #10 | Tourism; marketing; imagery; society; england behaviour; impairment; tourism |
| #11 | Website; social; accessibility; comparative commerce; search; engine; business; meta |
| #12 | Travel; market; experience; tourist; segmentation national park; area; sustainability |
| #13 | Development; sustainable; goal; sustainable tourism; inclusive; inclusion; refugee; framework |
| #14 | Wheelchair; user; heritage; assessment; interview tourism; tourist; challenge; wheelchair |
| #15 | Social; management; system; theory; systems inclusion; building; conservation; dementia |
| #16 | Access; vehicle; private; citizenship; systems inclusion; automobility aircraft; wheelchair; manual; passenger; flying |
| #17 | Travel; disability; education; health; priority constraint; education social; disability; health |
| #18 | Data too sparse to form a link |
| #19 | Accessible tourism; desired companion; inclusive tourism; leisure constraint; people with disabilities; recreation companionship; social intimacy; social network; social tourism |
| #20 | Accessibility; design for all; intellectual access; multimodality; multisensory; museum; orientation and mobility; sensory access; visiting experience; visual impairment |

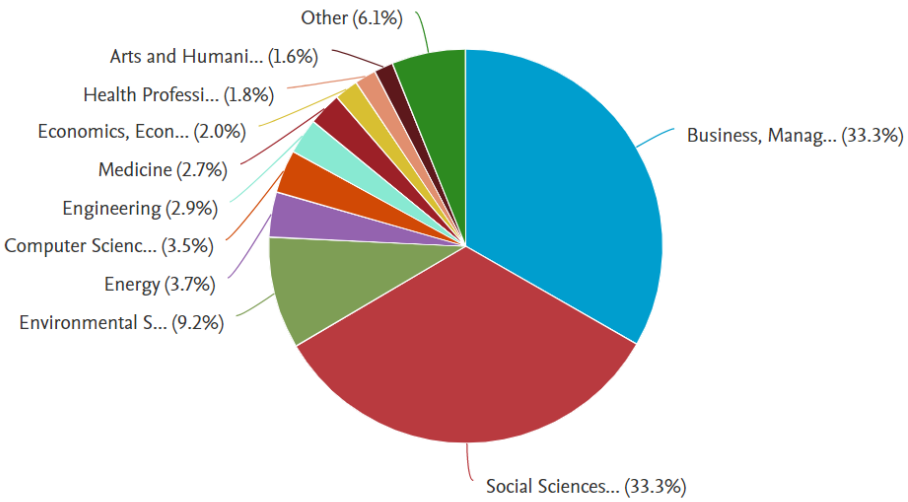
*Figure 11. Timeline diagram of keywords on AT research during the period 1997-2021.*



## Subject areas

The areas of knowledge and categories (directly determined from the Scopus database and Scimago journal rankings) associated with the most publications on AT are as follows (in descending order): Business, Management and Accounting/Social Sciences (both 33.3 %) and Environmental Science (9.2%) (See Figure 12).

*Figure 12. Document analysis depending on the area of knowledge.*

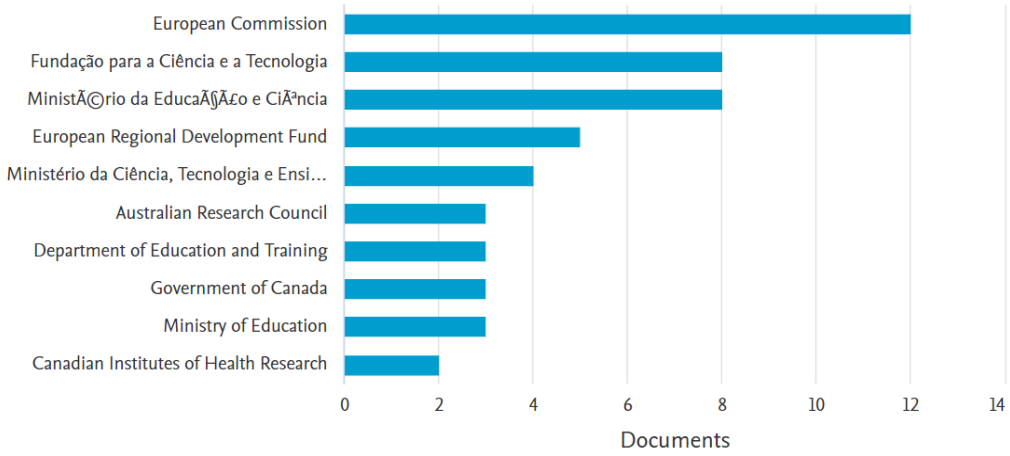



*Note*. The sum of percentages in the figure exceeds 100% since the studies are published in journals that can be simultaneously indexed in different areas of knowledge and categories.

## Financing

A total of 60 institutions provided financial support for the 254 articles analyzed. Thus, there is a wide array of funding agencies, none of which are particularly dominant. The top three organizations were, in descending order, the European Commission (*n* = 10 studies subsidized); Foundation for Science and Technology (*n* = 8); and 3rd Ministry of Education and Science (*n* = 8) (see Figure 13).

*Figure 13. Documents by funding sponsor.*




## Discussion

The objective of this bibliometric study was to analyze and map progress in scientific research on AT and tourism for all by studying past contributions to the field, its current status, and future trends based on the literature.

To achieve this objective, an analysis of research productivity was conducted using the Scopus database; specifically, our analysis involved a detailed examination of literature trends by year, country and institution, journal, author and co-citation networks, keywords, knowledge domains and funding institutions (sponsors).

Several bibliometric studies of great relevance and interest to researchers in the field of tourism have been carried out, such as those by Bastidas-Manzano et al. (2020) and Johnson and Samakovlis (2019), who reviewed the literature about smart tourist destinations, and that of Della-Corte et al. (2019) on the development of sustainable tourism in terms of open innovation. These studies are relevant to AT, where a tourist destination cannot be considered smart if it is not accessible; moreover, the contributions of accessibility to tourism sustainability are very clear (Darcy et al., 2010). However, few studies similar in nature to the present one were identified.

Given the paucity of previous bibliometric studies on AT, we decided to conduct a bibliometric analysis of literature published during a 24-year period

(1997-2021). Bibliometric analysis is a rigorous method for analyzing large volumes of scientific data (Donthu et al., 2021). This methodology has several advantages for the analysis of AT research: it can reveal emerging trends in articles, journals, and collaborations between researchers and can also be applied to explore the intellectual structure of specific areas of the literature.

The volume of publications within the field of AT has progressively increased, especially since 2016. However, the considerable attention that accessibility is attracting within the tourism sector, from a social and commercial perspective, does not necessarily correspond to the number of scientific publications thereon, albeit publications from more countries on this topic are now appearing.

According to the results of this study, the country with the most publications on AT is Australia, followed by the United Kingdom and Spain; significant international collaborations involving researchers from these countries were also observed. Hong Kong and South Korea, despite not having large numbers of papers on AT, also have extensive collaboration networks with other countries.

The top 10 most productive journals concerning AT research were tourism journals, whose overall objective is to promote understanding of tourism from a transversal and multidisciplinary point of view. One of the leading journals was identified as “Sustainability”. This international, interdisciplinary and open-access journal focuses on environmental, cultural, economic and social sustainability. The drastic increase in papers on AT published by this journal in 2020 may be attributable to the publication of the special issue "Disability, Tourism and Sustainability", which included seven such studies.

Our analysis indicated that the author with the highest number of publications, citations, and collaborations was Simon Darcy. In 2011, he edited the book “Accessible tourism: concepts and issues”, his most cited publication (n = 566). The authors of this publication sought to document AT's foundations and theoretical problems using a broad constructionist approach.

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Our cluster analysis of keywords showed how, along with AT, new areas of research are gaining prominence, such as ecotourism, virtual reality, inclusive tourism, the visions of sector stakeholders, and sustainability.

New types of tourism are beginning to appear, among which accessible ecotourism may be one of the most promising. Tourism has an important role in the social lives of people with disabilities. Accessible ecotourism can expand both the physical and social environment of people with disabilities (Gura et al., 2020).

In the same way, virtual reality, defined as a realistic environment comprising computer-generated scenes and objects, offers great opportunities to the different stakeholders in the tourism sector. On the one hand, it allows clients with special needs to experience hotels, museums and destinations prior to making travel decisions (Altinay et al., 2021), especially in heritage destinations where accessibility is often extremely limited (Marasco and Balbi, 2019). Similarly, the functions of smartphones and some mobile applications have proven useful for circumventing barriers to visiting tourist attractions (Lam et al., 2020).

To ensure that tourism services are accessible and inclusive for all, it is essential to consider the visions, opinions and perspectives of the different stakeholders involved in the sector's development (De La Fuente et al., 2020). In this scenario, value co-creation arises between clients and tourism providers, allowing services to be adapted to the clients' particular needs, especially those with disabilities. This promotes tourist satisfaction and brand loyalty (Navarro et al., 2015; Neuhofer, 2016).

An emerging field of research suggests that, in addition to taking into account the universal design strategy to achieve more inclusive tourism, social tourism policies and practices that advocate for more inclusive and sustainable outcomes for people who have disabilities should be prioritized (Darcy et al., 2010; Gillovic and McIntosh, 2020).

Our analysis of publications on AT by knowledge domain revealed that Business, Management and Accounting (33.3%), Social Sciences (33.3%) and Environmental Science (9.2%) were dominant. Several recent studies have

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assessed the value of AT marketing in different geographical regions, with the consensus being that it constitutes a business opportunity. Many of these studies were published in journals and related organs about business management and accounting (Luiza, 2010; Alén et al., 2012; Domínguez et al., 2013; Bowtell, 2015; Gondos & Nárai, 2019). However, given the pertinence of AT to the rights of people with disabilities, research should not neglect aspects such as the perceptions and needs of tourists with disabilities (Blichfeldt & Nicolaisen, 2011; De La Fuente et al., 2020) and not focus purely on the value or economic potential of this emerging niche market.

### Limitations

The present study had some limitations. The main drawback of this bibliometric analysis was that only one database was searched. Although this may have limited the scope of the results, Scopus is nevertheless among the major international databases, such that any studies not revealed by our search would likely not be relevant to this study.

Another potential limitation concerns the specificity of the proposed search. For example, the use of specific descriptors such as "Accessible tourism", "Tourism for all", "Inclusive tourism", and "People with disabilities" may have led to the omission of some literature related to AT, such as "Smart Tourism"; however, given the objectives of our analysis, we preferred to focus on studies that dealt with similar topics to facilitate comparison.

Finally, given the proliferation of concepts comprising each grouping, the keyword timeline was not ideal in visual terms. However, any attempt to reduce their number would have resulted in the dispersion of terms, preventing the formation of links between them.

## Implications

This study may have different implications for different stakeholders involved in the development of AT. For the academic/scientific field, it sheds light on emerging trends in AT, which shows the efforts made within the field and could guide new and more empirical research.

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We have shown how many different disciplines are required to advance AT as an interdisciplinary field. For example, information and communication technologies provide a basis for the design of future AT destinations. Technological tools can improve the tourism experience and tourist satisfaction since they can address areas such as planning (through virtual reality), reservations, transport, accommodation, and the plurality of needs of tourists according to their disability status and age (Pühretmair & Nussbaum, 2011; Ribeiro et al., 2018; Altinay, 2021).

Our study showed growing interest within the scientific community in the field of accessible and inclusive tourism. The contributions of this bibliometric analysis can be summarized thusly:

- The analysis of the most productive countries, institutions and authors could guide academics intending to engage in collaborations at a national or international level by helping them search for relevant papers and identify institutions and research centres amenable to collaborations on AT research.
- The analysis of productive journals could guide researchers concerning destinations for future publications on tourism, people with disabilities, on AT.
- As already mentioned, the temporal analysis of key concepts revealed hot subtopics/concepts within AT research. This could also guide future research.
- Our study also revealed funding sources and sponsors that academics could approach for future projects related to AT.

## Conclusion

This study presents a bibliometric analysis of the scientific literature on AT and reveals a general paucity of research to date. Although some countries, institutions, authors and funders have contributed to the field of AT for several decades, overall productivity is relatively low.

In closing, this paper synthesizes the research on inclusive tourism accessible to all. It is expected that the bibliometric information thus provided can serve as a basis for future research in this field. This study highlights the importance of accessible tourist environments to enhance tourists' satisfaction with disabilities and their families and friends, and may attract interest from researchers and professionals worldwide.

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# USER PERSPECTIVES OF ACCESSIBILITY AND USABILITY OF A PERFORMING ARTS THEATRE

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***Abstract:*** Older adults often have limitations due to normal ageing, which interfere with their ability to attend theatre performances. Mobility, visual, and hearing impairments can limit the experience older adults have as they engage in these cultural offerings. In this study, 20 older adults (age range 65-78 years; 15 females, 5 males) perspective of the usability and accessibility of the physical environment before and during a musical performance was studied for one urban performing arts theatre. Participants completed a self-assessment questionnaire, identified accessible features, barriers to access, and made suggestions for improvements. Results showed that the participants had mixed experiences, some participants mentioned accessibility limitations in the built environment, and others regarding communication access. Most participants would recommend the theatre to others. Following up on the recommendations will improve theatre access for any individual with mobility, visual, and/or hearing limitations.

***Keywords:*** universal design, older adults, aging.

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## Introduction

According to the Centers for Disease Control and Prevention (2020), two in five adults over the age of 65 live with a disability. Older adults have a higher incidence of disabilities than the general population, because typical ageing leads to a progressive decline of visual and auditory perception, motor, cognition, and memory functions (Krampe, 2002; Kraus, Lauer, Coleman, & Houtenville, 2018; Tye-Murray, 2020).

In fact, a majority of older adults have mobility (22%), hearing (14.6%), and vision (6.6%) difficulties (Kraus et al., 2018). Mobility limitations of older adults typically are associated with well-described pathological and neurochemical abnormalities in brain tissue that result in a variety of functional effects (Rowe, et al. 2006) impacting reaction time, posture, balance, and motor performance (Kattenstroth, Kolankowska, Kalish, & Dinse, 2010). These changes inhibit older adults' ability to participate in physical activities they previously enjoyed. Hearing loss increases with age and accelerates over time so that the hearing loss becomes noticeable when older adults enter their seventies (Tye-Murray, 2020). The slowly declining hearing impacts communication, social relationships, and enjoyment of sounds such as nature and music. Visual difficulties also impact older adults' ability to participate in some activities. The eyes undergo several physical changes with ageing, leading to declines in visual acuity, colour, contrast sensitivity, and poorer accommodation, amongst other visual limitations. These limitations result in difficulties with reading and navigating in environments with low lighting (Tye-Murray, 2020). The combination of all of these limitations often co-occurring in older adults further limits older adults' functioning (Crews & Campbell, 2004).

This higher rate of motor, hearing, and vision limitations also interferes with social participation (Crews & Campbell, 2004). Sustained interpersonal relationships and engagement in social and productive activities are important components of successful ageing (Rowe and Kahn, 1997) and enhance social, cognitive, and emotional well-being (Carr, Weir, Azar, & Azar, 2013). One of the events that fosters social engagement, belonging, and social well-being is theatre performances (Meeks, Shryock, & Vandenbroucke, 2018). The

importance of the arts to foster healthy ageing was the focus of the *Summit on Creativity and Aging in America* which highlighted health and wellness in the arts, lifelong learning in the arts, and age-friendly community design (National Endowment of the Arts and the National Center for Creative Aging, 2016). All the areas identified in the report enhance older adults' engagement and participation, but age-friendly community design, through the use of universal design specifically, allows for inclusivity. Their engagement and participation are facilitated when motor, hearing, and vision limitations are not interfering with the expected outcome of theatre attendance.

According to the United Nations (2006), all individuals in the community must have access to institutions for the performing arts as a basic human right. Older individuals, especially those with age-related disabilities, are often excluded from participating in social and cultural activities (Chen, 2013; Gallistl, 2021). Theatres have begun to recognize that accessibility is essential. Some theatres now include productions where American Sign Language, closed captioning, or a reduction in sensory stimuli are made available (The Hanover Theatre & Conservatory for the Performing Arts, 2021a).

In addition, the application of Universal Design (UD) principles afford access to all individuals in the community. UD is based on the concept that the design of environments should benefit all individuals regardless of their ability or age. The Center for Universal Design defines UD as "the design of products and environments to be usable by all people, to the greatest extent possible, without the need for adaptation or specialized design" (1997, para. 1). Products and environments are accessible without stigmatizing individuals needing accommodations because the intention in the design was to embed accessibility. The seven principles of UD are as follows: equitable use, flexibility in use, simple and intuitive use, perceptible information, tolerance for error, low physical effort and size and space for approach and use (Center for Universal Design, 1997). One well-known example of UD is curb cuts that allow any individual using a wheelchair, using a stroller, or walking independently to access the sidewalk without difficulty.

UD design has to a large extent focused on the physical and visual domains. The hearing domain has been limited to electronic materials and ways to

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enhance distance learning. Jennings (2009) adapted the UD principles to include guidelines for individuals with hearing loss. She stated that the design of an environment must enable a person to enter a space and to hear "without expending considerable cognitive or physical effort" (Jennings, 2009, p. 253). UD must be applied not only to the built environment but also to the experience of the individual in the built environment. The experience must be enhanced so that individuals are able to participate and to engage (Jennings, 2009).

Jennings (2009) developed Universal Design for Hearing (UDH) and the first three guidelines can be applied to older adults' access to a theatre environment. The first UDH guideline is to optimize the hearing environment, including attention to reverberation time, background noise levels, and to improve intelligibility. The second UDH guideline is to optimize the interaction between persons or objects to promote better hearing in an environment, for instance distance between speaker and listener or the maintenance of and positioning of objects. In a theatre it may imply optimal seating, use of hearing assistive technology (HAT) and optimal functioning of HAT. The third UDH is to optimize the opportunities for people to choose the type of interaction they need, for example, one on one, or one to many. In a theatre environment it may imply listening to another person, and to hear the performance.

Many public spaces in urban settings benefit from an examination of ways in which to incorporate Universal Design for optimal access of individuals with physical, vision and hearing limitations. The Centre for Excellence in Universal Design stated that a single design should be accessible to as many users as possible without the need for modifications (National Disability Authority, 2014). However, it is impossible for a single design to accommodate 100% of the population, in which case alternative options should be provided. These alternative options may be obtained from the users so that their lived experience can inform the developers to co-produce value and a more accessible and usable environment (Cluley & Radnor, 2020). Users with hearing loss, for instance, added value to an art museum's docent-led tours. Suggestions to institute regular checks of hearing assistive technology, using clear speech during presentations, and providing written information to supplement the docent's presentation contributed to a more accessible

experience. Not only users with hearing loss, but also users with English as a second language, or other communication disorders will all benefit from these suggestions (Meyer, Larrivee, Venziano-Korzec & Stacy, 2017).

Although theatres in the USA must comply with the Americans with Disabilities Act to create accessible and usable experiences, for instance, wheelchair spaces, accessible routes, and bathroom spaces (US Department of Justice, 2010), these changes may still not provide the user with a good experience. In addition, there is no research available on how users perceived theatre accessibility and whether their needs were met. Therefore, the purpose of this project was to investigate how older adults, most with self-identified limitations, perceived the accessibility and usability of the same theatre. This is the only performance arts theatre in a medium-sized city however, the investigation may benefit all performing art theatres.

## Methodology

This project was approved by Worcester State University's Institutional Review Board (1920-0003). The authors received a 2019-2020 Faculty Scholarship/Creative Activity Grant through their institution.

### Participants

An email describing the study was sent to community-dwelling older adults over the age of 65 who were known to the researchers. The investigators contacted the participants by phone or email and provided them with verbal and written descriptions of the study. Through snowball sampling (initial participants recommended additional participants, Portney & Watkins, 2015), a total of 20 community-dwelling older adults agreed to participate in the study (age 65-78 years; 15 females, 5 males). The participant pool was limited by the grant's funding for theatre tickets. The participants did not have known medical diagnoses but self-identified with at least one limitation in mobility, vision, or hearing typical of older adults (Table 1). All participants were able to attend the theatre production and lived within 30 miles from the urban setting.

*Table 1. Participant Characteristics.*

| Self-Identified Limitations | Number of Participants | Percentage |
|---|---|---|
| Mobility | 3 | 15 |
| Hearing | 1 | 5 |
| Vision | 7 | 35 |
| Hearing and Vision | 4 | 20 |
| Mobility and Vision | 1 | 5 |
| Mobility, Vision and Hearing | 4 | 20 |
| **Total** | **20** | **100** |

## Instruments

A demographic questionnaire was used to learn more about the participants. Information was gathered about age, gender, and self-identified limitations in the areas of mobility, vision, and hearing. The Accessibility and Usability Survey, developed by the investigators, consisted of three main sections: mobility, vision and hearing with nominal-type questions (Yes, No, Not Applicable). An additional column was available for open-ended recommendations for any barrier noted. This survey was designed for the participants using the principles of The Community Health Environment Checklist (CHEC) (Stark, Hollingsworth, Morgan, & Gray, 2007).

## Procedures

This was a descriptive, quantitative survey study with open-ended recommendations regarding the participants' perceptions. All participants agreed to attend the same theatre performance on a weekend afternoon. Although the theatre staff were aware of the study, they were unaware of the specific chosen performance. The specific procedures included the following:

- One month prior to the performance, each participant received and signed the informed consent. They also received a complimentary

parking pass, a demographic questionnaire, and the Accessibility Survey.

- One week prior to the performance, participants were reminded and encouraged to review all three sections of the survey. Participants were asked to arrive 1-hour before the performance to determine the accessibility of the theatre. They also were asked to plan to stay after the performance to evaluate their experience.
- On the day of the performance, the participants met with investigators and were debriefed on the surveys. The participants' tickets were in various sections of the auditorium section of the theatre to provide different perspectives of the performance. All participants were able to complete the survey before, during, and after the performance. They then returned all surveys to the investigators at the end of the performance.

## Results

The data were analyzed using IBM® SPSS® Statistics (Version 27; IBM Corp., Armonk, NY) for the nominal-level data (Yes, No, Not Applicable), and frequency counts and percentages were generated. Open-ended recommendations were reviewed and categorized into codes (positive or negative) in Microsoft Word. The results in Table 2 summarized the features the participants identified as accessible and usable.

*Table 2. Accessible and Usable Features Identified by UD Principle.*

| UD Principle | Perception by Older Adults |
|---|---|
| Equitable Use | Helpful employees<br>Elevator was available |
| Flexibility in Use | Helpful employees |
| Simple and Intuitive | Bathrooms were accessible |
| Perceptible Information | Hearing Assistive Technology available<br>Clear speech used |
| Tolerance for Error | Ushers friendly and helpful<br>Located seat easily |
| Low Physical Effort | Opened doors easily |
| Size and Space for Approach | Sink, soap and paper towels easily accessible |

Their perceptions were grouped according to UD principles. It was noticeable that the theatre employees were one of the reasons why the UD principles of equitable use, flexibility in use, perceptible information, and tolerance for error were perceived positively. These helpful employees and ushers contributed significantly to the accessibility and usability of the theatre. The availability of an elevator, bathrooms with accessible features such as sink, soap and paper towel dispensers at the appropriate height, doors that are easy to open and availability of HAT indicated the universal design principles of simple and intuitive, low physical effort, and size and space for approach and use were identified as accessible and usable. These features also added to the previously discussed principles of equitable use and perceptible information.

In Tables 3 and 4, the participants identified the barriers they experienced as well as suggestions for improvement of the accessibility and usability of the theatre.

*Table 3. Barriers and Recommendations for Performing Arts Theatre: Built Environment.*

| **Locations** | **Barriers Indentified** | **Recommendations** |
|---|---|---|
| Outside walkways | Not smooth | Paving needed |
| Main Lobby | Very noisy | Improve acoustics |
| | Difficult to manoeuvre | Improve flow of traffic |
| | Minimal seating | Increase seating options |
| Hallways | Very crowded area | Remove obstacles |
| | Difficult to navigate | Improve flow during intermission |
| Balcony | Very steep staircases | Ability to self-disclose about limitations during purchase transaction |
| | No tread on stairs | Add treads to stairs |
| | No handrails | Designate ushers to assist |
| | Carpet pattern was distracting | Change carpet pattern |
| Bathrooms | Not enough single use bathrooms | Modify existing bathrooms |

*Table 4. Barriers and Recommendations for Performing Arts Theatre: Communication.*

| Location | Barriers | Recommendations |
|---|---|---|
| Verbal Communication | Non-functioning HAT* | Designate employee to check HAT* |
| | No open captions | Provide captioning |
| | Difficult to hear ushers | Retrain ushers on clear speech |
| | Oral announcements hard to hear | Provide written announcements |
| Visual Communication | Font on playbill too small | Increase font and format |
| | Poor signage from carpark | Relocate signage |
| | Elevator sign not clearly visible | Improve size, contrast, font and location |

*HAT = Hearing Assistive Technology

Some of the participants felt that there were not enough bathrooms available during the intermissions. The doors were also heavy and there was no single-use bathroom. The recommendations for improvement were mainly focused on more available bathrooms, the need for handrails to balcony seats, smooth pathways, and decrease the noise levels in common areas.

One communication barrier identified by the participants was that even though HAT were available, some were not functional. A recommendation was that a specific employee should be allocated to check the technology before each performance. Other communication limitations included a lack of open captions available and the small font size of the playbill making it difficult to read. In addition, although the ushers were typically described as very helpful, some of the participants mentioned that ushers were not easy to hear and that they should receive training to speak more clearly. Participants also noticed that the signage from the car park and in the theatre could be improved.

The results in Table 5 show that as a group, all participants, except for one individual with vision limitations, rated their theatre experience positively (93.8-100%).

*Table 5. Older Adults' Perception of Accessibility and Usability.*

| **Self-Identified Limitations** | **Positive Experience** | **Recommend Theatre for Individuals with Same Limitations** |
|---|---|---|
| Mobility | Yes = 8 (100%) | Yes = 7 (87.5%)<br>No = 1 (12.5%) |
| Vision | Yes = 16 (100%) | Yes = 15 (93.8%)<br>No = 1 (6.2%) |
| Hearing | Yes = 8 (100%) | Yes = 7 (77.8%)<br>No = 1 (11.1%) |

Although the total theatre experience was overwhelmingly positive, at least one individual in each group with a mobility, visual, or hearing limitation felt that the theatre's barriers were significant. Specifically, they noted a lack of signage, lack of smooth walkways, noisy lobby, steep stairs to the balcony, and distracting carpet. Therefore, although most participants would recommend the theatre to others, these few participants would not recommend the theatre to another person with similar limitations.

## Discussion

Based on the results of The Accessibility and Usability Survey, the theatre was found to be largely accessible to older adults. Many structural accessible features in the built environment were identified in addition to good customer service support. The participants specifically mentioned the helpful and friendly employees and ushers. These employees have had extensive training by the theatre management (personal communication), but a refresher in using clear speech could assist communication with these older adults. Barriers to access were also identified and recommendations were made to improve the overall accessibility of the building.

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Recommendations for improvements were mainly focused on the need for handrails due to the steep stairs to balcony seats, better signage from the car park and in the theatre, smoother pathways, and decrease in the noise levels in common areas. Participants also mentioned the need for improved HAT maintenance, open captions, and a larger font size in the playbill. Using the Accessibility Survey, older adults rated their theatre experience positively. They felt that individuals with hearing, mobility and vision issues may need additional assistance including their recommendations to access and use the theatre.

When considering UD principles in the evaluation of a theatre, not only mobility and vision but also hearing must be considered. The inclusion of all these three aspects will ensure both participation and engagement by older theatre goers. Accessible and usable theatre performances foster social engagement, belonging, and social well-being in older adults, (Meeks et al., 2018), all important components of successful ageing.

Participation and engagement must be enhanced by UD not only in the built environment, also in the theatre experience. To achieve that enhancement, Jennings (2009) suggested that UD must include accommodations on a micro, meso, and macro level.

On a micro level, the theatre must be evaluated by considering the space and what people need to do in it (Jennings 2009, p. 252). The theatre in the study is a historical and renovated theatre building. It was built in 1903 with sweeping staircases, and seats 2,300 audience members in front of the stage as well as on balconies. The building is typical of early 20th-century entertainment architecture. The theatre was renovated and restored in 2008 (The Hanover Theatre & Conservatory for the Performing Arts, 2021b). The retrofitting of this structure led to some of the limitations mentioned by the participants, such as the steep staircases without handrails.

At the meso level, the theatre must be evaluated by considering how people conduct activities within the constraints of the environment, culture, and established procedures (Jennings 2009, p. 252). The participants were able to attend the performance and rated their experience positively, however the environment provided constraints. These constraints were, for instance, noise

levels, limited seating in public areas, and non-functional HAT. Continued training of all employees when interacting with older adults and individuals with disabilities is imperative in providing an accessible and usable cultural experience.

On the macro level, the theatre must be evaluated regarding the "factors within the environment that may or may not be conducive to change and the availability of resources to support change" (Jennings 2009, p. 252). The building, built-in 1904, has limited the opportunities for changes due to available space and structural constraints (The Hanover Theatre & Conservatory for the Performing Arts, 2021b). For example, an elevator had to be installed in a less visible space. The management had to consider priorities such as available space and resources in the retrofitting of stairs and handrails.

At the end of the study, feedback on the perceptions of the theatre's accessibility and usability was presented to the theatre's director. The recommendations were favourably received by the theatre director and chief executive officer. Several of the issues were addressed in recent renovations, such as the improvement of the outside walkways and signage. Scheduled training regarding interactions with older adults and theatre patrons with disabilities, specifically using clear speech, will continue for all employees. This is an example where theatre management in collaboration with the theatre patrons' lived experiences co-produce value, or a more accessible and usable theatre experience (Cluley & Radnor, 2020). Future research should include additional studies that offer more user perspectives about the value and barriers encountered in various contexts and the lived experience of those typically aging, with and without disabilities, as well as other demographic groups.

## Conclusion

To facilitate successful ageing and sustained engagement in social and productive activities such as the theatre, older adults' higher rate of motor, hearing, and vision limitations must be considered. Although theatres must comply with the Americans with Disabilities Act (US Department of Justice,

2010), it is unclear how older adults perceive their own theatre experience regarding accessibility and use. The group of older adults with self-identified motor, visual, and hearing limitations provided useful feedback on their theatre experiences. Their recommendations were in line with the principles of UD, and providing the suggested improvements will benefit all theatre patrons as well as older adults and individuals with disabilities.

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# FACULTY PERSPECTIVES ON INTERPROFESSIONAL COLLABORATIONS BETWEEN OCCUPATIONAL THERAPY AND INDUSTRIAL DESIGN: A QUALITATIVE ETHNOGRAPHIC INQUIRY

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***Abstract*:** Incorporating a user-centred approach to universal design solutions improves functionality and access for a more diverse group of individuals to engage with end products within everyday environments successfully. Interprofessional collaborations between industrial design and occupational therapy are one approach that integrates a user-centred universal design perspective throughout the design process, as occupational therapists have unique expertise in understanding how individuals participate in activities and engage with everyday products and environments.

This qualitative ethnographic inquiry explored faculty perspectives (n=5) involved in interprofessional academic collaborations between design and occupational therapy at the university level in the Northeastern United States. Five themes emerged: 1) "Benefits of Collaboration:" Improving the Design Process; 2) "Benefits of a Mutual Approach:": Supporting Design Learning; 3) Interprofessional Awareness and Education Approaches "Help and Hinder" Collaboration Efforts; 4) Benefits and Challenges to Accessing: "Navigation of the Obstacle Course"; and 5) "Minding the Gap:" Professional Education and Training. Findings suggest that interprofessional collaborations between

occupational therapy and industrial design via an embedded model positively impact design outcomes and influence student and faculty learning during the design process, clarify educational objectives, and prepare student industrial designers for future professional practice.

***Keywords:*** occupational therapy, interprofessional collaboration, interprofessional education, student, user-centred design.

## Introduction

Disciplines such as industrial design and occupational therapy have become increasingly aware of the need to develop and explore collaborative methods and processes that mutually forward both professions' ability to advance and serve their users and clients (Mollo & Avery, 2017; Amiri, Wagenfeld, Reynolds, & 2017). In the industrial design profession, a "user" can be defined as the individual who experiences and engages with an object, product, or environment (McDonagh & Thomas, 2013). In the occupational therapy profession, "clients" are defined as individuals whose active participation in daily activities is impacted by illness or disability, limiting well-being and ability to fully engage in society (Schell, Gillen, & Scaffa, 2014).

In clinical practice scenarios, occupational therapists treat individuals throughout the lifespan. They complete intake interviews, evaluate performance using skilled observation, apply clinical reasoning, implement standardized testing procedures, and deliver interventions based on scientific evidence (American Occupational Therapy Association [AOTA], 2020). Occupational therapists use, modify, or both, available fabricated objects, products, and built environments created by industrial designers to better ensure active meaningful engagement and independence in daily tasks and activities to the extent possible (Murphy, Panczykowski, Fleury, & Sudano, 2020). On the front end, industrial designers support users (and occupational therapists) by developing and integrating universal design solutions that aim to address user needs and improve the lived experience when interacting with objects, products, or the environment for as many individuals as possible

(Amiri, Wagenfeld, & Reynolds, 2017; De Couvreur & Goossens, 2011; Young, Wagenfeld, & Vander Veen Rocker, 2019).

Many industrial designers are now employing participatory design, user-centred design, and co-creation practices, which involve the active inclusion of users and other stakeholders to identify, understand, and address user needs during the iterative design process (Sanders & Stappers, 2014). Emerging research in the design professions indicates that it is critical to incorporate the user perspective to achieve successful functional and universal end products and environments (Boman, Nygard, & Rosenberg, 2014; McDonagh & Thomas, 2013; Medola, Sandnes, Ferrari, & Rodrigues, 2018). An effective way to obtain this type of input during the iterative design process is through interprofessional collaboration, a common approach employed in healthcare settings and education (Reeves et al., 2016). Wagenfeld, Reynolds, & Amiri (2017) noted that 33% of occupational therapists had worked in an interprofessional design project and 31% of designers had worked with occupational therapists; 88% of the occupational therapists who had participated in these types of interprofessional experiences reported the desire for more opportunities for interprofessional collaboration. Prior documented partnerships between occupational therapy and industrial design suggest interprofessional collaboration enhances user-centred solutions in design; however, the amount of literature specifically describing collaboration in educational and/or professional settings remains limited (Lee, 2016; Young, Wagenfeld, & Vander Veen Rocker, 2019).

## Background

In 1986, Norman and Draper introduced the term user-centred design as “the need for a design that uses the natural properties of individuals…focusing on the needs and interests of the user, in order to make the final products usable and understandable” (as cited in Luna et al., 2015, pg. 967). Design professionals have incorporated user-centred approaches in design practice to increase idea generation, decrease the number of revisions required in the iterative process, and increase the usability for individuals who will experience and engage with the end product (Lee, 2016; McDonagh & Thomas, 2013; Medola et al., 2018; Veryzer & Borja de Mozota, 2005). Early principles

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of user-centred design led to the development of emerging design philosophies intended to increase the direct relationship between users and designers; these include participatory design, co-creation, co-design, and "Design for All" (Bucchianico, Gregori, & Rossi, 2012; Sanders & Stappers, 2008; Tsekleves & Cooper, 2017). In these approaches, designers, scientists, engineers, programmers, doctors, psychologists, or nurses incorporate users into the academic and/or design research experience as collaborators, rather than inspirations, to capitalize on the users' lived experience and inform solutions to complex day-to-day issues impacting participation in daily activities and experiences with end products and services (Driver, Peralta, & Moultrie, 2011; Hu, Hu, Lyu, & Chen, 2021; Orfield, 2018; Sanders & Stappers, 2008). With user-centred design methodology, design professionals and co-collaborators from a variety of backgrounds have produced positive user outcomes for a range of end products and services, such as videophones for individuals with dementia, assistive devices and technologies, web-based decision aides, outpatient oncology facilities, as well as other personal health tools (Bogza et al., 2020; Boman, Nygard, and Rosenberg, 2014; Carmel-Gilfilen & Portillo, 2016; De Couvreur, Detand, Dejonghe, & Gossens, 2012; Orfield, 2018; Vaisson et al., 2021).

While user-centred design approaches bring designers closer to human-centered universal design solutions, there continues to be a gap in designers' existing knowledge of users' needs and the translation of these needs into sufficient solutions (Ielegems, Herssens, & Vanrie, 2016; Kim, Liu, & Joines, 2015). Designers' and organizations' self-identified barriers to applying user-centred approaches included lacking expertise in communicating with users and limited access to user populations (Carmel-Gilfilen & Portillo, 2016; Hu et al., 2021). Another barrier explored was the user's direct access to contribute to the design process, for reasons such as cognitive decline and decreased verbal skills (Orfield, 2018). Under these circumstances, other stakeholders supplemented or captured the views of the individual (Boman, Nygard, and Rosenberg, 2014).

An identified solution to address these barriers is to develop multidisciplinary design teams and practice via interprofessional collaboration (Boman, Nygard, and Rosenberg, 2014; McDonagh & Thomas, 2013; Watchorn et al., 2019).

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Interprofessional teams help to improve collaboration as professionals share multiple viewpoints and enhance knowledge to increase innovation (Larkin, Hitch, Watchorn, Ang, & Stagnitti, 2013; Pirinen, 2016; World Health Organization, 2010). When creating products with interprofessional team members that work closely with the intended users, designers develop an increased awareness of users' needs, identify "pain points" or problem areas that impact user experience more quickly, and have greater access to testing populations, which can allow solutions to have increased user adoption rates and universality (McDonagh & Thomas, 2013; Silver, Binder, Zubcevik, & Zafonte, 2016; Wagenfeld, Reynolds, & Amiri, 2017).

More recently, findings indicate it is beneficial for designers to collaborate with healthcare providers to address health-specific problems related to chronic conditions or ageing in place (McDonagh & Thomas, 2013; Wagenfeld, Reynolds, & Amiri, 2017; Young et al., 2019). Occupational therapy serves as a healthcare profession with a unique skill set to enhance the design. Occupational therapists can demonstrate value to the design process by being able to promote understanding of client factors and function for the diversity of users and support understanding for designers as to how people living with all types of physical and mental health conditions can and do participate effectively in everyday life and when interacting within their environments with the proper support (Amari, Wagenfeld, & Reynolds, 2017; Hitch, Larkin, Watchorn, & Ang, 2012; Lee, 2016). They also contribute knowledge to designers about how health products are used and distributed to individuals with disabilities (Lee 2016; Medola et al., 2018; Wagenfeld, Reynolds, & Amiri, 2017). Evidence suggests that in-depth knowledge of user needs and health conditions can support effective design (Ielegems, Herssens, & Vanrie, 2016), with the most successful user-centred design solutions designed for universal access (Hitch et al., 2012; Buccianico, Gregori, & Rossi, 2012; Watchorn et al., 2019). Some documented examples of effective interprofessional collaborations between occupational therapy and industrial design include the development of a videophone for adults with dementia and user-specific products such as glasses for an adult with ankylosing spondylitis (Boman, Nygard, and Rosenberg, 2014; De Couvreur et al., 2012; McDonagh & Thomas, 2013; Young et al., 2019).

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Interprofessional collaborations between occupational therapists and industrial designers are emerging in recent literature (Hitch et al., 2012 Wagenfeld, Reynolds, & Amiri, 2017; Young et al., 2019). Available literature acknowledges that barriers such as biases, misperceptions, and lack of resources impact the initiation of professional collaborations (Dong, 2010; Larkin et al., 2013; Wagenfeld, Reynolds, & Amiri, 2017; Young et al., 2019). One proposed solution to address these barriers is to incorporate increased interprofessional collaborations between these professions at the academic level in order to address misconceptions and embed a collaborative way of thinking from the onset of professional training (Larkin et al., 2013; Wagenfeld, Reynolds, & Amiri, 2017; Young et al., 2019). To support an increase in collaborations at the university level, evidence suggests further research is necessary to incorporate outcome measures that capture a broader perspective of student learning and document novel curricular methods applied during interprofessional experiences. (Dong, 2010; Larkin et al., 2013; Hu et al., 2021).

## Methodology

The development of this qualitative ethnographic inquiry was formulated around available anecdotal evidence from previous user-centred, co-creative, participatory design interprofessional collaborations occurring at Thomas Jefferson University in the Northeastern United States, which were modelled to embrace emerging trends in design focusing on healthcare's role in user-centred solutions (Bucchianico, Gregori, & Rossi, 2012; Silver, et al., 2016; Sanders & Stappers, 2008; Tsekleves & Cooper, 2017; Veryzer & Borja de Mozota, 2005). Current literature presented earlier in this paper accounts for student and professional perspectives within occupational therapy (Larkin et al., 2013; Mollo & Avery, 2017; Brown et al., 2021; Wagenfeld, Reynolds, & Amiri, 2017). To date, faculty perspectives and insights gleaned from these types of interprofessional collaborations remain underrepresented (Dong, 2013; Hu et al., 2021).

This qualitative ethnographic inquiry aimed to capture faculty members' experiences and perspectives from prior and current implementations of

interprofessional collaborative opportunities between occupational therapy and industrial design students at Thomas Jefferson University in the Northeastern United States. Identifying barriers and defining which collaborative learning experiences and processes were successful can help to identify, clarify, and focus on educational objectives and prepare industrial design and occupational therapy students and their faculty to participate in future interprofessional co-creational engagement experiences beyond academia into the professional realm where products are brought to market (Dong, 2013; Hu et al., 2021).

## Embedded teaching and learning coursework model

Collaborative opportunities between industrial design faculty and occupational therapy faculty have been ongoing between respective departments at Thomas Jefferson University since 1999. Experiences have ranged from short one-week intensive collaborative problem-solving experiences to three-month semester-long projects where students and faculty worked together interprofessionally to create a product that improved access for a user with a disability or illness or to support populations experiencing a health condition that limited access to the environment.

In 2018, the duration of the collaboration experience was expanded. Over the course of one academic year, two third-year doctoral-level occupational therapy (OTD) students were embedded in an industrial design curriculum alongside 18 first- and second-year master's industrial design (MSID) students, three industrial design faculty, and one occupational therapy faculty to provide on-going, embedded opportunities for aligned learning and collaboration. Both OTD students attended and participated in MSID courses, studios, and field experiences. To support interprofessional awareness and education, the OTD students developed and executed educational modules for MSID students, which included pertinent content on health conditions, experiential learning activities using adaptive medical equipment within context related to individual function and participation associated with illness and diagnosis, interdisciplinary perspectives on the comparison and application of occupational therapy and design theories, and task/activity analysis—methods utilized by both professions independently to breakdown

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steps required to complete a task or activity. To further enhance the interprofessional collaborative experience and to improve interprofessional awareness of the other, the OTD and MSID students also completed individual and group design projects, including, but not limited to, the development of a toy/game, creation of a product to support the needs of a caregiver for an individual with a chronic health condition, and problem-based learning for various other non-health-specific design issues. Detailed and technical information about the specific components occurring in this expanded educational experience and subsequent products created is available in a previous article published by the authors; refer to Brown et al., (2021).

## Data collection

A 45-minute semi-structured interview consisting of six open-ended questions explored occupational therapy and industrial design faculty perspectives on previous and current academic design collaborations experienced between occupational therapy and industrial design students at undergraduate and graduate curricula levels (*Table 1*). Faculty were recruited by the two OTD students via email in January at the start of the spring semester. All interviews were audio-recorded with consent and data were de-identified to protect privacy.

Exempt approval was obtained by the university's IRB board; all questions were piloted to confirm clarity of intent and reviewed by the occupational therapy department chair and two university faculty outside the fields of industrial design and occupational therapy.

Table 1: Semi-Structured Interview Questions.

| **Question 1:** | How did you find out about this collaboration? What about it intrigued you? |
|---|---|
| Prompt: | *[for industrial design faculty]* Why partner with occupational therapists? |
| | *[for occupational therapy faculty]* Why partner with design? |

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| | |
|---|---|
| **Question 2:** | What I am trying to uncover are the benefits and obstacles associated with embedding occupational therapy doctoral students in design curricula. I am interviewing faculty members to understand their perspective and experience within these collaborations. What do you see as the benefits, if any, of collaborations between occupational therapy and design students? |
| Prompt: | Do you think there are any gaps *[in your profession/in society]* that a collaboration of this type/nature fulfils? |
| **Question 3:** | As an instructor, have you noticed any changes in student performance and outcomes throughout this collaboration? |
| Prompt: | If so, what changes? Can you give any examples? |
| **Question 4:** | In your opinion, compared to past years' projects, has this year's collaboration impacted the outcomes of your design project(s)? |
| Prompt: | Can you tell me more about the specific projects you are thinking of? In what way were they impacted? |
| **Question 5:** | Are there any on-going barriers preventing successful collaborations between occupational therapy and design? |
| Prompt: | If yes, can you elaborate? |
| | What are your suggestions to address any issues you just identified? |
| **Question 6:** | If you could envision an ideal interprofessional collaboration between occupational therapy and design, what would that look like? |
| Prompt: | What are your thoughts about these types of collaborations in the short-term vs. the long-term? |

## Participants

Convenience sampling was used to identify three (male) industrial design faculty participants (with 5 years, 11 years, and 20 years of teaching experience), and two (female) occupational therapy faculty participants (with 4 years and 35 years of teaching experience) who had previous or current experience with interprofessional design collaborations at the university.

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### Data analysis

Data analysis was completed using NVivo 12 software. Audio recordings of each interview were manually transcribed and cross-verified by investigators. Observations and interpretations taken during and after each interview were noted with NVivo 12 to maintain an audit trail. Transcribed interviews were coded, resulting in the emergence of five overarching themes and 15 sub-themes *(Table 2)*.

## Results

*Table 2: Themes and Subthemes.*

| | |
|---|---|
| Theme 1: | "Benefits of Collaboration:" Improving the Design Process |
| Subthemes: | *1.1: Defining the user and understanding user complexity*<br>*1.2: Supporting research process & assisting in contextualizing findings*<br>*1.3: Supporting problem identification & design direction*<br>*1.4: Developing skills necessary for professional success* |
| Theme 2: | "Benefits of a Mutual Approach:" Supporting Design Learning |
| Subthemes: | *2.1: Defining the interaction as embedded*<br>*2.2: Consistent access changes attitudes*<br>*2.3: Ability to effectively engage in increasingly complex design challenges*<br>*2.4: Embedded collaboration model aligns well with teaching model* |
| Theme 3: | Interprofessional Awareness and Education Approaches "Help and Hinder" Collaboration Efforts |

| | |
|---|---|
| Subthemes: | *3.1: Collaboration vs. teamwork vs. cooperation*<br>*3.2: Overlap of language, processes, and theories*<br>*3.3: Importance of recurring awareness sharing* |
| Theme 4: | Benefits and Challenges to Accessing: "Navigation of the Obstacle Course" |
| Subthemes: | *4.1: Barriers to access*<br>*4.2: Lasting professional alliances* |
| Theme 5: | "Minding the Gap:" Professional Education and Training |
| Subthemes: | *5.1: Design training in integration of concepts and users*<br>*5.2: Occupational therapy training in device design & object use* |

## Theme 1: "Benefits of Collaboration:" Improving the design process

Situated in the context of industrial design curricula, and concurrent with recent findings suggested by Watchorn et al., (2019), Young et al., (2019), and Murphy et al., (2020), industrial design faculty consistently reported that on-going collaboration with occupational therapy students provided a level of expertise that improved the design process at various stages. The faculty noted that, in comparison to other healthcare experts, occupational therapists 1) possess expertise that is generalizable to the majority of topic areas due to the "psycho-behavioural, social foundation" [OT] of occupational therapy, and 2) serve a dual-purpose as an expert on diverse users, and a situated user themselves when analysing health-related design projects.

> "OTs actually serve several purposes within an ID classroom, you are experts on people and human ability, you are experts on the area of disability and how products can become part of solutions in an integrated way within that context, and then the third thing that you

> are is you are just a representative kind of healthcare provider person. So, if we are designing things for contexts of healthcare, you've got the right mindset and you've been working in the right contexts that you can have an informed and valuable opinion about things that happen. And so, to a certain extent you can be both the experts on product users and the experts on yourselves as product users. And in that healthcare context, we need expertise in both areas. So, you can kind of double up." [DES]

### *Subtheme 1.1: Defining the user and understanding user complexity*

Identifying and defining the characteristics of the individuals that will be using a given product is a foundational stage of the design process. However, industrial faculty noted that industrial design students have difficulty imagining users with different characteristics than themselves or characterising users at the moment of design, without regard for change, which is supported by findings from Driver, Peralta, and Moultrie (2011) and Hu et al., (2021). With access to the expertise of occupational therapy, faculty reported that industrial design students developed an increased understanding of the complexity of users, such that a single user can change over time, presentation of health characteristics may vary across individuals, and designing for the average user does not capture the needs of extreme/diverse users, which is supported by DeCouvreur et al., (2012).

### *Subtheme 1.2: Supporting the research process & assisting in contextualizing findings*

Industrial design faculty reported that research is a daunting task for industrial design students, who often experience difficulty narrowing down methods for information gathering and analysing/comparing research, which is supported by Pirinen (2016). Occupational therapy students alleviated the time and effort spent in this phase by directing industrial design students to relevant concrete evidence and/or provided experiential evidence. Additionally, occupational therapy students helped to contextualize findings—categorizing findings based on whether it is generalizable or unique to a specific user—so that the research informed meaningful products, which are all aspects of daily

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clinical practice in the occupational therapy field (American Occupational Therapy Association [AOTA], 2020).

### *Subtheme 1.3: Supporting problem identification & design direction:*

Faculty identified that a difficult transition period in the design process is learning how to identify gaps or problem areas in research and address them through actionable design ideas, evidence supported by Sanders and Stappers (2014). Here, designers must choose which idea to develop and the most effective method to address the problem. Collaborating with occupational therapy students provided industrial design students with access to novel frameworks and processes that identified how problems present in everyday life, as well as provided structure for determining effective solutions, which is supported by findings in Young, Wagenfeld, and Vander Veen Rocker (2019).

> "Already I can see that students are spending much more of their time finding and engaging with real problems and finding and engaging with real people rather than just casting around trying to understand what the success metrics for dealing with or even what the success metrics are for understanding the basic tenants of the disabilities that they are working on are." [DES]

### *Subtheme 1.4: Developing skills necessary for professional success*

Industrial design faculty considered both student development and the ability for a product to meet users' needs as important outcomes of working through the design process. Experiencing another discipline's approaches and ways of thinking, industrial design students developed broader definitions of key skills, such as problem-solving and the ability to identify all possible users and their needs, which is supported by McDonaugh and Thomas (2013). These skills were developed through collaborative experiences with healthcare-focused design projects, which were made possible through interaction with occupational therapy, as will be elaborated in *Theme 2.3*. Both occupational therapy and design faculty described that designing effective healthcare solutions requires a complex understanding of the relationship between multiple users and stakeholders, as well as how to make design decisions that account for all mentioned perspectives.

## Theme 2: "Benefits of a Mutual Approach:" supports design learning

The embedded model for collaboration was defined as regular and consistent participation of occupational therapy students within an industrial design curriculum over the course of two semesters. In line with the ethnographic model of inquiry, occupational therapy students learned about design by collaborating, consulting, and participating in industrial design courses and projects alongside the design students. This model was compared to other collaboration models typically implemented and delineated in interprofessional research between disciplines (Larkin et al., 2013; Reeves et al., 2016; Silver et al., 2016), whereby students collaborate on a single design project for no more than one semester. The differences noted by occupational and industrial design faculty between the embedded model and the single design project model are based on their prior experiences participating in or observing the methods mentioned above and understanding the benefits and barriers to both ways of collaborating.

### *Subtheme 2.1: Defining the interaction as embedded*

While only in its first year of development, industrial design and occupational therapy faculty noted that describing the interaction as "embedded" provided enough structure to describe the interfacing experience between disciplines while allowing for natural assimilation, development of interprofessional awareness, and room for error or "experimental interactions or just happy accidents" [DES]. Both occupational and industrial design faculty reported other interprofessional collaboration models can be restricted by course objectives, syllabi, or scheduling limitations, barriers supported by findings in Driver, Peralta, and Moultrie (2011), Luna et al., (2015), Mollo and Avery, (2017), and Veryzer and Borja de Mozota (2005).

### *Subtheme 2.2: Consistent access changes attitudes*

Occupational therapy and industrial design faculty reported that access to other disciplines provided interactions that improved students' interprofessional skills. A collaboration model where students are embedded within the same curriculum provided more touchpoints for interaction-based

outcomes to develop. The accumulation of small, unplanned experiences over longer periods of time was projected to change attitudes better than models with limited opportunities for snap experiences, which is supported by McDonagh and Thomas (2013), Hu et al., (2021), and Veryzer and Borja de Mozota (2005).

### *Subtheme 2.3: Ability to effectively engage in increasingly complex design challenges*

As mentioned throughout Theme 1, occupational therapy students provided support to increase efficiency and enhance the stage outcomes of the design process. Consistent support from occupational therapy students over two semesters allowed industrial design faculty to assign more complex projects which required increased time, resources, and expertise, as opposed to standard design projects studying color or form. Industrial design faculty noted that complex solutions became attainable within the same time frame due to the collaborative participation of occupational therapy students, which is supported by the findings in Amiri, Wagenfeld, and Reynolds, (2017) and Young, Wagenfeld, and Vander Veen Rocker (2019).

### *Subtheme 2.4: Embedded collaboration model aligns well with the teaching model*

Industrial design faculty described the design teaching and learning process as one that involves students participating in and completing "project-based experiences" [DES]. Faculty assumed that throughout the design process, when industrial design students faced particular challenges with process stages, they would reach out for help. When provided with the necessary terminology and methodologies in the face of a challenge, the industrial design faculty believed the design student better valued and retained the learned material. Industrial design faculty stated that the embedded collaboration model aligned well because interaction and expertise are available as challenges arise instead of other collaborative methods that can hinder progress if access and learning are not aligned, which is supported by findings in Ielegems, Herssens, and Vanrie (2016), Larkin et al., (2013), Pirinen (2016), and the World Health Organization (2010).

### *Theme 3: Interprofessional awareness and education approaches "Help and Hinder" collaboration efforts*

Interprofessional awareness and education were identified by occupational therapy and design faculty as a necessary catalyst for collaboration. Faculty reported on-going collaboration led to a well-developed understanding of the partner profession's terminology, theories, and processes, which enabled participants to effectively play to the strengths of both disciplines, with a necessary awareness of gaps in knowledge, to produce a greater outcome, as supported by Hitch et al., (2012) and Hu et al., (2021). When bringing together two disciplines from different content areas, such as occupational therapy and industrial design, faculty described the processes of interprofessional awareness and education become increasingly important.

#### *Subtheme 3.1: Collaboration vs teamwork vs cooperation*

Bringing two disciplines together to complete a project does not automatically constitute collaboration; all faculty stressed this, defining the difference between teamwork, cooperation, and collaboration. As described by faculty, teamwork is the result of professionals who share the same methods, goals, and mindset coming together to complete a shared goal. Cooperation is the result of professionals from different fields addressing separate parts of a solution relevant to their skillset and only merging to pair the parts to complete a solution, which Dong (2010), Larkin et al., (2013), and Hu et al., (2021) confirmed serves as barriers to collaborations and limits opportunities for successful product development. Whereas the main indicators that a project is collaborative are that both parties have equal buy-in and responsibility, and there is reciprocal respect for the knowledge of the other professional so as not "to try to do somebody else's thinking for them" [DES]. Faculty suggested that each profession is afforded the space to approach the problem using their field-specific methods, goals, and expectations while seeking a balance to ensure that similarities and differences between disciplines are effectively employed and embraced to achieve the shared goal, which is also supported by findings in Veryzer and Borja de Mozota (2005).

### *Subtheme 3.2: Overlap of language, processes, and theories*

All faculty acknowledged efforts to share and experience another profession's terminology, theories, and processes enable a level of interprofessional awareness that allows disciplines to collaborate and support one another effectively. Faculty agreed that this type of educational experience solidifies students' own professional identities, understanding of other discipline's approaches, and the opportunities available when developing relationships between two disciplines, which is suggested by Hu et al., (2021). Faculty reported this type of collaborative model allows for a higher-order perspective on the collaboration process, such that students will not only see a completed project through the lens of their own contributions, but they will also have repeated opportunities to understand the contributions of others, with the belief that shared understanding enhances mutual respect, which supports findings in Bowman, Nygard, and Rosenberg (2014).

### *Subtheme 3.3: Importance of recurring awareness sharing*

All faculty suggested that oftentimes, in collaboration, interprofessional awareness and education are explored at the onset of the partnership to build rapport and to establish roles and responsibilities, which is supported by Larkin et al., (2013) and Pirinen (2016). However, one faculty participant [DES] with 20 years of experience with collaboration, noted the value in revisiting interprofessional awareness to continue the translation of knowledge and process, as well as the potential to prevent conflict between participating professionals, which has also been noted in Hu et al., (2021). Faculty advised recurrent sharing at different points within a single project and across multiple projects over time would maximize benefit.

> "Again [conflict arose] because we didn't explain ourselves to each other, so I keep going back to the very early days when I had [occupational therapy faculty] in the back of my class and I realize that was, when we were explaining what we did, that was probably what needs to keep happening every so often so we can keep the project fresh and keep the understandings fresh and it won't be a grinding between the instructors." [DES]

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## Theme 4: Benefits and challenges to accessing: "Navigation of the Obstacle Course"

A reason for collaborating with other disciplines is the opportunity associated with access, as suggested by Tsekleves and Cooper (2017). In one sense, "access" can mean access to one's time and expertise. In this perspective, when collaborating or consulting with designers, industrial design faculty noted that occupational therapists are providing access to their expertise with the goal of improving outcomes, which has been suggested prior by McDonagh and Thomas (2013) and more recently by Watchorn et al., (2019). Industrial design faculty also noted that "access" can be defined as access to resources, such as opportunities to interface with user groups or entry into vital environments for research that designers may not be able to access without a network.

### *Subtheme 4.1: Barriers to access*

While benefits exist, all faculty admitted that institutional barriers exist that can impact opportunities for access. At the academic level, not specific to occupational therapy and industrial design, collaborative partnerships may fail to form due to differences in course objectives, scheduling, expectations, or educational standards. For example, [OT] faculty reported the Accreditation Council for Occupational Therapy (ACOTE) limits faculty from seeking collaborations to make room in curricula beyond essential courses. Additionally, industrial design faculty pointed out that restrictions, such as health clearances, required vaccinations, and privacy standards, limit design students from accessing vulnerable users or environments even with a point-person or referral by occupational therapy.

### *Subtheme 4.2: Lasting professional alliances*

All faculty described that when collaboration and other disciplines' expertise and approaches are accessible, the impact can exist longer than the extent of the collaborative experience. Faculty noted that multiple students and other faculty report maintaining contact and reference to/with collaborative partners for clinical or professional problem-solving, affecting positive skill development and project outcomes even after the conclusion of an initial

collaborative experience, all of which support suggestions made by Hu et al., (2021) to improve innovation and entrepreneurial abilities post-graduation.

## Theme 5: "Minding the Gap:" Professional education and training

Collaboration between occupational therapy and industrial design occurring at the academic level was reported by all faculty to address gaps in the implementation of professional education and training, noting a positive impact on student learning for both professions, which supports evidence that has been previously reported by Boman, Nygard, & Rosenberg (2014), McDonagh and Thomas (2013) and Watchorn et al., (2019). Faculty also identified that collaboration between occupational therapy and industrial design is underreported within professional training and in the real world, and there is a need for more institutions to implement and research these types of collaborations.

### *Subtheme 5.1: Design training in the integration of concepts and users*

Industrial design faculty described that in current design education, there is a gap in how students understand and frame users, a finding which is consistently reported in the literature (Lee, 2016; Medola et al., 2018; Wagenfeld, Reynolds, & Amiri, 2017). Specifically, students homogenize users and characterize them as static individuals falling within the average or the high-performing extreme. Additionally, industrial design faculty shared that while design programs include a project in their curriculum for unique populations or healthcare, these projects are often viewed as separate from designing for the population at large, and because of this, a gap exists in the integration of the two concepts, which Hu et al., (2021) suggests, remains an on-going concern for designers to date. As described in Subtheme 1.1, industrial design faculty reported that occupational therapy involvement served to change design students' perspectives about users, such that users are complex, dynamic, and work in systems with other non-users and their environment. Additionally, due to occupational therapists' expertise within and outside of healthcare, industrial design faculty reported that design students integrated previously separate concepts to consider the needs of all

user groups into their design solutions, which is supported by Youg, Wagenfeld, and Vander Veen Rocker (2019).

### *Subtheme 5.2: Occupational therapy training in device design & object use*

Occupational therapy and industrial design faculty identified that there remains a clear gap in the professional training for how occupational therapy students are taught to create and adapt devices for clients to use in their daily life, a concern cited in Mollo and Avery (2017). Occupational therapy faculty noted that occupational therapy as a profession continues to demonstrate the lack of knowledge towards processes or material use by describing the typical use of "duct-tape and cardboard" [OT] for object creation—objects typically developed for the use of individuals to complete tasks for daily living or safety. Occupational therapy faculty also reported that access to designers and the understanding of their processes and approaches to problem-solving assist in an occupational therapy student's ability to use objects and adapt devices for clients in a functional, stable, and sustainable manner. Finally, occupational therapy faculty identified that occupational therapists typically design objects for the use of a single client; however, collaboration with designers has the potential to educate occupational therapists in making design choices to scale these objects to meet the needs of multiple users.

> "We are designers in a way, but we don't know it and we don't frame it that way, so I think that collaboration offers occupational therapy students to learn about design from a designer rather than the way that typically in OT programs we teach design as create an adaptive device that meets the needs, so we are designing something, but we know nothing about design." [OT]

## Discussion

The development of this qualitative ethnographic inquiry was formulated around available anecdotal evidence from previous interprofessional collaborations occurring at a university in the Northeastern United States and emerging trends in design and healthcare in literature with a focus on

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occupational therapy's role in user-centred solutions. Findings provided additional perspective on interprofessional collaborative experiences from the faculty viewpoint between occupational therapy and industrial design, uncovering rich themes highlighting the strengths, barriers, and outcomes associated with these types of collaborations at the collegiate level. Our findings validated, through a novel faculty perspective, occupational therapy's positive impact on the design of user-centred products (Dong, 2010; Larkin et al., 2013; Murphy et al., 2020; Watchorn et al., 2019; Young, Wagenfeld, & Vander Veen Rocker, 2019). Barriers to collaboration, such as awareness of the scope of practice and access to networks (Driver, Peralta, & Moultrie, 2011; Hu et al., 2021; Wagenfeld, Reynolds, & Amiri, 2017), as well as barriers impacting the translation of user needs to products (Hu et al., 2021; Ielegems, Herssens, & Vanrie, 2016; Kim et al., 2015) was also further supported by the faculty perspective. Finally, this qualitative ethnographic inquiry helped to describe industrial design faculty participant perspectives indicating that incorporating an occupational therapy lens throughout a long-term, year-long embedded model of collaboration within an existing design program helped to address these types of barriers.

Faculty findings further support occupational therapists as well-positioned to impact user-centred design solutions in interprofessional collaborations; the findings of this qualitative ethnographic inquiry suggest that this impact occurs at multiple levels. On one level, access to occupational therapy's knowledge base, expertise, and network of users improved industrial design students' skillsets while consistently emphasizing the importance of considering the universality of all users and their needs throughout the various stages of the design process (Watchorn et al., 2019). For example, in previous research, designers were reported to experience difficulty translating the needs of users to design solutions (Dong, 2010: Ielegems, Herssens, & Vanrie, 2016; Kim et al., 2015), however, as demonstrated in *Subthemes 1.2 and 1.3*, on-going collaboration with occupational therapy appeared to address this barrier—supporting industrial design students' ability to contextualize gathered research and translate the problems into actionable design solutions. On another level, integrating occupational therapy and industrial design collaboratively in academia is seen to not only change student perspectives,

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as proposed in the literature (Larkin et al., 2013; Wagenfeld, Reynolds, & Amiri, 2017; Young, Wagenfeld, & Vander Veen Rocker, 2019) but doing so also bring awareness to gaps in professional training and suggests possible solutions, as demonstrated in *Theme 5*, meaning that the embedded collaborative experience improves student problem-solving and user-analysis. Acknowledging the impact of this embedded collaboration model on student learning and industrial design outcomes at this institutional level supports the continuation of this model as it reduces barriers identified in *Subtheme 4.1*— course objectives, scheduling, educational standards, or restrictions such as health clearances.

While the findings of this qualitative ethnographic inquiry indicate that collaborations with occupational therapy reduce barriers impacting design, participatory observations throughout the collaborative experience identified that while reducing some barriers, new barriers arose. For example, previous research identified that designers experienced difficulty engaging with users who could not participate in the design process due to cognitive or verbal challenges (Boman, Nygard, & Rosenberg, 2014). Through collaboration, the OTD students addressed this barrier by serving as proxy users; however, the industrial design students appeared to have a unique difficulty translating this knowledge to design solutions. Working within embedded teaching and learning coursework model over an academic year, all faculty reported the students experienced more interprofessional awareness than other collaborative models that occurred over shorter time frames. The literature and supporting evidence in *Theme 3* on interprofessional awareness and education suggest that on-going interprofessional practices should reduce this barrier (Larkin et al., 2013; Pirinen, 2016; Hu et al., 2021). Additionally, the embedded collaboration model provided the industrial design students with consistent access and opportunities to ask for clarifications or further information, yet industrial design students had to be reminded by faculty on several occasions to take advantage of this assistance. Further research needs to be completed to identify whether there exists a threshold to the amount of access that is beneficial between disciplines and what knowledge strategies are most effective to enhance communication between both disciplines.

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## Limitations

This qualitative ethnographic inquiry represents the informed opinions of one private university system in the Northeastern United States. Transferability of the findings are limited to programs with similar institutional structure and opportunity for collaboration. As an emerging practise area, the number of eligible faculty participants with years of experience and comparison models was limited. The perspectives shared by the faculty participants from both professions, while informed by experience and observation, are the sole opinions of those participants. Had another sample population been accessed, themes and subthemes may have varied. Each faculty participant varied in level of experience teaching and amount of time spent collaborating with occupational therapy and industrial design. For example, two faculty participants had nine months' experience, and another, 20 years in an occupational therapy and industrial design collaboration. Similarly, the ability to compare models of collaboration is impacted by the fact that one model has been sustained for 20 years, while the embedded model, lasting one academic year, was in progress during the time of data collection.

Due to the nature of the doctoral occupational therapy curriculum and timeline under which this qualitative ethnographic inquiry was conducted, the findings are limited in the level of triangulation and time available to complete data analysis. In order to fulfil doctoral academic requirements, data collection was implemented by the OTD student during the fifth and sixth months of the nine-month (one academic year) embedded collaboration. Therefore, the findings and discussion of outcomes for the embedded model are limited by the faculty participants' experience to date.

## Conclusion

Having explored the collaboration process and the outcomes associated, this qualitative ethnographic inquiry of faculty perspectives contributes to the growing knowledge supporting occupational therapy's role in interprofessional collaborations to develop user-centred universal design solutions. The qualitative ethnographic inquiry methodology used was able to capture and

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uncover further significant concepts linking the impact of occupational therapy in the context of collaboration to interprofessional student learning outcomes, approaches to the design process, and addressing gaps in both the industrial design and occupational therapy professional education. While themes and subthemes suggest that any level of collaboration that incorporates interprofessional awareness and access to resources proves positive, the additional components identified in the embedded collaboration model facilitate higher-level skill development. For example, if any level of collaboration between occupational therapy and industrial design improves the learned design process, then the consistent access and flexible interaction associated with the embedded collaboration model will also improve the learned design process, even as it applies to complex design challenges.

The above findings advocate for further research into the approach, structure, and implementation of collaborative programs and processes, especially embedded models. Diverse research efforts are needed to validate the preliminary findings outlined in this qualitative ethnographic inquiry and the impact of those findings at the academic and professional level on students, professionals, and the occupational therapy and design fields.

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# Appendix 1: Themes and Supporting Excerpts from Interviews

## 1. Collaboration Impacts the Learning of Design Process

### *1.1 Defining the User & User Complexity*

“They are realizing that it’s not as monolithic as they would have thought. For instance, you know thinking about people on the autism spectrum, they are realizing this could take all different forms and they are understanding the challenges better of design for that there is not one solution that is going to work. Like ultimately if they wanted to do thesis they can't say that I've created this product or system that is going to treat people with autism—they are going to have to be more specific about that. And, clearly by the way they are talking about this stuff, I think that they appreciate that. I also think that the collaboration has done a good job of making them understand that, these situations are all dynamic and that are not static. They are changing all the time and I think that is another dimension that OT involvement has brought to this, because the fact that you guys are you are improvisers and that you've made it clear that you are always dealing with, or not always, but often dealing with a changing situation as somebody either improves, or their condition changes or you know if they have a degenerative condition and its getting more difficult to deal with; I think that that the discussion about that kind of stuff has been really good for the students to understand that they can't just design one thing that just kind of sits there that is always going to work. We have a tendency, and again this goes back to basic design training and curriculum, we have a tendency to think that we, that most of the products we design are for the user as we can conceive of them at the time we design and that that situation is never going to change.” [DES]

“So, industrial design students tend to, like most people, they reflexively assume that everyone is able-bodied and fully competent mentally all the time and they are not really sensitized to the fact that everybody has impediments or difficulties at some point in their life. So I think that the perspective that you guys bring to it is really important. And I think that it extends beyond the immediate accessibility/caregiver project, I'm hoping that this sort of on-going exposure will sensitize them in general to kind of automatically think about

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the fact that they are not just designing for all of their fully cable-bodied, 20 something year old peers. I'm hoping that it changes mindsets a little bit." [DES]

### *1.2 Research Methods & Contextualizing Findings:*

"There is no way that the industrial design students would be able to, they would just be overwhelmed if they tried to do online searches and random interviews. So I think that the benefit of having [occupational therapy] involved is to contextualize everything…" [DES]

"It's very different to hand someone a book or have them watch a taped TED talk on a disability because then as soon as they have questions or as soon as they have data that doesn't fit what the canned information was that they saw, they are going to start suspecting that information, and they are going to re-open the can of worms rather than having somebody that can sort of immediately explain how the corpus of content and knowledge in the field connects to the new observations that our students are making. I think that's the biggest thing here. That industrial design and especially the graduate industrial design here it's very much about field observation and data gathering, so students tend to come back with baskets of relevant and irrelevant information and they spend a lot of time just trying to set up theoretical frameworks within which to evaluate the things that they've seen and attach valid interpretations to what they've seen; having someone who can be at their side to give them frameworks for interpreting their observations rather than having them have to build that from sticks that they are finding in the forest, is moving them forward so much more quickly and so much more effectively than the previous approach which you know has, as a prime exponent of the approach, which I still characterize as kind of a blind bumbling." [DES]

### *1.3 Problem Identification & Design Direction:*

"Already I can see that students are spending much more of their time finding and engaging with real problems, and finding and engaging with real people rather than just casting around trying to understand what the success metrics

for dealing with or even what the success metrics are for understanding the basic tenants of the disabilities that they are working on are." [DES]

"I think even the way that you, that OT as a profession classifies things and you know you have that taxonomy that you work with. I think that was a big eye opener for the design students. It was for me as an industrial designer because I didn't know that that existed and I think another benefit of that is for design students when they approach problems of accessibility they tend to get a little overwhelmed like they don't know where to start, and they either get stuck or they go in a direction that doesn't make sense sometimes so I think that's particularly, even thinking back on past capstone projects that I've advised students on, the undergrads, that's where projects have gone off the rail, because I've seen design students sort of go down a particular path without, based on their design intuition but not based on solid enough research or interaction with the population that they are designing for." [DES]

### *1.4 Marketable Outcomes:*

"What I think is that particularly with OT involvement, I feel like your perspective can be valuable for almost any design project. Just because I think you are better tuned into as a profession, than the average design student is, to how somebody physically and cognitively might interact with an environment or a product. My hope would be that this becomes kind of more integral, I think it does have the potential to give us sort of a leg up on other design schools." [DES]

"You can take a designed product and ask OTs to critique and validate it." [DES]

"A good designer is serving multiple constituencies. Obviously, our primary duty and interest is to serve product users, but often products have more than one set of users. And often the customer, the person who makes the buying decision on a product, is not the same as either of those sets of users. And healthcare is a really interesting model there, where that is the usual situation where the customer is not the payer, and the payer is not the first user of the product, and the first user of the product is not the patient, who is generally also the user of the product. And designing products within a healthcare

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context is kind of the equivalent of New York City in the old song, where if you can make it there, you can make it anywhere. If you can understand a situation where you're dealing with insurers and hospital administrators and the people who work in the supply chain, and then the medical direct healthcare professionals that are facing the patients, and then the patients, and then their families, and the stakeholders in this process. If you can design effectively in this context—oh and I forgot all the regulatory issues, and the technology requirements around this—if you can do this, you can do anything. I often told my students that if you've got a healthcare product in your graduating portfolio, you can get a job designing water bottles, you could get a job designing sneakers on the basis of that; if you have sneaker or a water bottle in your portfolio, could you get a job designing medical products from [x healthcare company]? You probably couldn't. It doesn't go both ways. But designing in a healthcare context is an excellent way to demonstrate that you've mastered the complexities of the industrial design profession at a high level because there is so much to take into account and understand." [DES]

## 2. Embedded Model Supports Design Outcomes

### *2.1 Defining the Interaction*

"I think it's a pretty good word actually because it doesn't necessarily define what the interaction is going to be, but it defines what the location and the adjacency and the availability is going to be which I think has really been kind of a problem in the past, we've tried to define exactly what the interaction is going to be without making room for experimental interactions or just happy accidents that can happen." [DES]

"I think that the way this played out this year where we sort of just started with the two of you kind of observing was useful and the barriers in the past have been, and I can't quite articulate how, but we have run into problems in the past, that the OT project that the juniors do where, when we've had grad students involved because there was definitely a difference in approach between industrial design students and the OT students and that led to a couple conflicts because I don't think that those two student groups understood each other very well going into the project. You know they dove

into the project, they met with the client, the industrial design student started doing what industrial design students do, and that wasn't necessarily the way OT students would approach things and that led to some conflicts in the past." [DES]

### *2.2 Consistent Access Changes Attitudes*

"I had gone to a design for health care conference about a year and a half ago and the recurrent issue is access to caregivers and health care professionals. In fact you can't get into the hospital often enough to really make that meaningful. So it tends to be really sporadic, you kick of a project with some health care professionals and then the students go off and do their thing and they present it at the end, but there is no on-going involvement, and I feel like that we are really well-positioned to go to gain an advantage in that respect." [DES]

"I think that doing it over the long term is really valuable. I think that the two of you have brought a different perspective, even like some of the questions you ask occasionally are just different than what a designer would ask and I think that's been, that continues to be useful even in projects that don't involve accessibility. Those little opportunities for the two of you to provide input would be really hard, would be a lot harder to get at if this was just sort of a sporadic thing where you just kind of came in for either a given project or for like a two studios and then you were gone, and I'm inclined to think that that on-going involvement is more, is does a better job at sort of changing attitudes that sort of the one shot or one project kind of involvement brings." [DES]

### *2.3 Take on Increasingly Complex Design Challenges*

"Some things we might not have taken on had we not had the OT access. The fact that we're doing the circular economy and emergency medicine project, one of the reasons that we thought that was appropriate was because, again OT would be really great at helping students. Otherwise that project might have gone by too quickly for students to do the necessary research into the context of care and how the humans involved in receiving the care might have been, that would have been a heavy research to ask, and as it is, we know

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that they are going to have another couple of weeks of access to you guys to validate some of that stuff, and also to a certain extent its valuable that you can be experts on humans." [DES]

### *2.4 Integrates Collaboration with Teaching Model*

"I think more important challenge is linked to the way that we do teaching and learning in design. Where rather than take a bunch of content and present it to the students and test them on it until they are good at it and assume that the learning is happening and the relevance of that content will eventually become clear, either intellectually or in the course of practice. What we tend to do is we set up learning as a series of project based experiences. and we wait until the students are challenged by particular difficulties in achieving the stage goals of the project at which point they will reach out to us generally for more information in the course of our studio teaching, and that point we know that the students will value methodologies and the terminology and the ways of thinking that we are going to hand them at that point because they need it then. The problem with that in terms of the interaction with other disciplines, is it doesn't always happen at the same point of a project and we like to be able to wait until the students says I need habit of mind x will you give it to me, and then we hand it over. Last night in class, we actually had this moment where a student was saying I've met and I've interviewed these 4 people with autism, who could possibly put this in context? I'm like whoa dude, you need to talk to OT at this point because they can absolutely talk to you about issues that these people have in common and where the overlaps are and whether they are off to one side or at the top or in the middle of the general run of people with conditions like this, and he's like "I'm going to go do that immediately." That's a real success for us with a project like this because it lets actually stream another discipline and their expertise into the teaching methodology that we use." [DES]

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## 3. Interprofessional Awareness and Education Approaches Help and Hinder Collaboration

### *3.1 Collaboration vs. Teamwork vs. Cooperation*

“I think the, one always makes a mistake as a professional when you try to do somebody else's thinking for them.” [DES]

“One of the big things about collaboration for it to be effective, interprofessionally, both sides have to have equal buy-in and equal responsibility and equal respect for each other’s knowledge, and it has to have reciprocity too. Without those elements it’s not going to work.” [OT]

“When we became [an integrated university] the prediction was that every project was going to be [health/medical-based], and I said but that would be really sad. That's not the idea, the idea is to keep the disciplines the disciplines and here are these really neat things where they can have these crosses where we can work.” [DES]

“The real test of how it all started was the fact that we started sharing vocabulary and looking for commonalities as opposed to looking at what was different about our two things. And I've seen other collaborations start around here and not go very far because it’s all about the differences, it’s not, ‘we do it this way and that’s positive’; it’s, ‘oh well we don't do it that way.’” [DES]

“Yes absolutely, absolutely. I think it’s tough because it shouldn't be you're the designer you build the thing, I'm the OT I know everything about the client. It should be, you know just as much about the client as I do and I know just as much about the device and how it came to be as you do. And therefore where we do this trick where we have everybody swap the explanations where the ID person presents the client and the OT person presents the object. That sort of cements that deal. Where there were years where I said that and we got crickets because they weren't able to do that. They had each done their own parts, that's cooperating, that's not collaboration. So I don't look at the cooperating years as sort of a high point of the program, that's all.” [DES]

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“Understanding the differences between those things as well as what I spoke of before, the really interesting underlying commonalities between the disciplines, those were really really interesting things to uncover and I think it’s very valuable for students to understand that just because you are collaborating with someone in another discipline this doesn't mean that you have the same goals, and this doesn't mean you share the same methods in getting to those goals, and it doesn't mean that you share the same mindset in moving towards those goals, and in fact if collaboration is defined as we define it here in industrial design, that it is making an idea better by working with people who bring things to the table that you can't; it’s actually better that they are working with different mindsets and different standards and different expectations. If you were working with someone where you do share all those things, chances are working on a team, but you wouldn't be doing collaboration. And if we as a university have staked a lot on this idea of nexus learning, which is all about learning to work and learning to learn in a collaborative way, and we don't know what we mean by collaboration, it’s going to be really hard to get there. And so this understanding of the deep methods of values of collaboration is one of the big things that working with OT can bring to industrial design and I'm hoping the corollary of that is also true and you are getting that from working with us.” [DES]

### *3.2 Overlap of Language, Processes, and Theories*

“I think that the fact that we have sort of started off more slowly didn't dive right into a project but just had a period in which we sort of got an acquainted I think that that helped break down some of the barriers a little bit and I would definitely advise going forward that we do something like that, where we either spend time with you with the OT students kind of observing or we do for you kind of what you did for us and give you sort of a primer on the design methodology and the kinds of research that we traditionally do. So just to you know a sharing exercise, so that we sort of get to understand each other better before we actually start working on projects together. But I think that's the biggest potential barrier.” [DES]

“It meant we had to sit down for many hours and compare vocabulary and that's really where the whole magic, we call it this, oh you call that that, we

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call this this and we measure it this way oh well we don't call it that, we call lit this, and we don't measure it, we just take that and it was this whole amalgamation of thing, this patchwork quilt of completing each other's sentences but we didn't know the language of each other and we came up with the principle… that the OTs advocate for the user of the product and the designers of course advocate for what the product is able to do and if we swapped roles in the class our successes went up." [DES]

"That's where the real transfer of knowledge and some of the methods that are used in projects came from, introducing each other's tools, like how we do 7-14-28 task tool analysis, COPM is right out there and we did just an overlay of the two, and it's just a difference of just some difference of granularity, we probe deeper in this area and you probe deeper in that area, and then over time how do you assess the clients' needs as the clients are matched up to the OTs and how do you take that pair and match it up to the design students, it didn't always work, very difficult. There were some screaming matches early on...but the essence was, we say you need to get down on the ground and work in order to understand your performance, and that is exactly what needs to happen in occupational therapy. You need to get down and work with the client to know how you impact change or affect change, bring about change, so that was again common ground." [DES]

"So it's been a tradition since I guess the second or third time we presented and it as really just a whim because we were sharing vocabulary and it was really interesting to hear the interpretations that we got. It was important to me that the industrial design students understood how to speak about the person as the whole person, again, core OT values. The whole person, and not a disability, not a disease, not a problem, not a condition, and never even occurred to use the word patient in any way, and yet that does crop up earlier. So in thinking about it, I said well, what if always the ID person whenever they talk about the project, in class, to me, publicly, and definitely when they make the representation, they always have to describe the client. You know, how do you find this person? What are their abilities? What are their desires? What's their environment like? Again, person, environment, occupation right, how do you do that? And it's such an important part of what we do as industrial designers, but it comes across as universal design principles which I don't really

subscribe to, you can't write it down and codify it, it's a thing you feel. So that was really great because the industrial design students in explaining the client publicly before the device was explained, were taking ownership of their understanding like I built my understanding into this thing that you're about to see and here's my understanding , and so that's part of it, and then was "this thing", and I heard a lot of "this thing" and it does "this" and all "this thing", and I heard a lot of what the principles were behind it, when the OTs were talking about the device, and I said, it's a product, what do you mean this thing? It's the reacher-grabber, it's not this thing, give it a personality! And so by having and [OT professor] felt this was really true, by having the OTs present the product in particularly talking about the decisions that were made, the fact that there were choices, there were iterations, we tried it this way, and we tried it that way, what it was doing it was building and since it was a portfolio project especially, it was building the valuable part of this, which is you'll never make that device again, but the process that got it there and the decision making capability and the observational skills, those are what somebody is going to hire when they hire an OT or bring them in, and so having the OTs present the object and do it as though it were a client almost." [DES]

### *3.3 Importance of Recurring Awareness Sharing*

"Again [conflict arose] because we didn't explain ourselves to each other, so I keep going back to the very early days when I had [occupational therapy faculty] in the back of my class and I realize that was, when we were explaining what we did, that was probably what needs to keep happening every so often so we can keep the project fresh and keep the understandings fresh and it won't be a grinding between the instructors." [DES]

## 4. Benefits and Challenges to Access

### *4.1 Barriers to Access*

"I know that there are all kinds of like HIPAA restriction son doing that, and I don't know how practical that is but I think that would be really useful." [DES]

"There are gaps because nowhere in the ACOTE standards does it talk about teach OT students about design" [OT]

### *4.2 Network Maintenance*

“I do know that there are people who become really good friends with their industrial design partners and when they see each other you see them outside, you see them both going a million miles an hour all the ideas still do together and things like that, so there is definitely lasting friendships that come out. And when our industrial design students hit their capstones they are usually knocking on the door of the old OT mentor and showing me everything or talking to their old OT partners for their perspectives and things so there are those kind of things that happen and that's what we love to see too.” [OT]

## 5. Collaboration Addresses Gaps in Professional Education & Training

### *5.1 Design Training in Integration of Concepts & Users*

“Projects tend to sort of separate into two worlds: you're working on a project for the population at large and you just kind of assume that everyone can do everything that you can, and then we also have sort of every design school will have design projects that either involve design for people who are handicapped in one way or another, or disabled in one way or another, or you design for special population; but those projects tend to sort of stand by themselves. I think oftentimes what is missed, is the integration between those two worlds. And I think there is a little bit of a gap in thinking there. We talk about it a little, and it's probably written up and talked about in some of the journals, but I don't think it’s embedded in most design training as much as it should be.” [DES]

### *5.2 Occupational Therapy Training in Device Design & Object Use*

“We are designers in a way but we don't know it and we don't frame it that way, so I think that collaboration offers occupational therapy students to learn about design from a designer rather than the way that typically in OT programs we teach design as create an adaptive device that meets the needs, so we are designing something but we know nothing about design.” [OT]

“There are gaps because nowhere in the ACOTE standards does it talk about teach OT students about design. You know there is nothing blatantly that says

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that, you know that I know, so I think that I will kind of repeat what I said that all OT curriculums include teaching OTs how to adapt an object, and how to create an assistive device. We learn that from day one, we adapt, we adapt, and we take something and make it easier for someone to do. So the gap is that, as I said, we are not teaching the principles of design as how you go about modifying a device, we are just modifying a device without understanding that. So I think that's a gap that this fulfills." [OT]

"They are always really afraid of what happens if it doesn't work, and then through the process they learn a lot of flexibility like they come in very type A, because that's just who tends to come into heartache, that's just who we are, like very concerned about deadlines which you need to be because documentation is a different story, but what happens if doesn't work what happens if we don't come up with something good. It's not about that, so through the process I feel like they become a little more flexible I feel like they become a little bit more willing to roll with the punches, they learn that the process is way more important than the outcome a lot of the times and they seem more willing to take risks, which I think is really important because we have to be able to go in with an idea and just see what happens and then be able to change it in the moment to make sure things end up OK, even in the field. I'll say they become OK honestly a little bit with failure, like it's OK that things didn't work and we talk about what we learned and that's a good thing." [OT]

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# SONIFICATION OF INFORMATION SECURITY EVENTS IN AUDITORY DISPLAY: TEXT VOCALIZATION, NAVIGATION, AND EVENT FLOW REPRESENTATION

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***Abstract*:** This research is dedicated to developing an information security tool with a sound interface. If there is a possibility to manage information security by ear, analysis of computer attacks could be effectively maintained by people with vision problems. For this purpose, a human-computer interface is required in which the signs of malicious code and computer attacks are encoded using sounds. This research highlights the features returned by the console tools for static analysis of executable files, as well as an audio coding method for auditory expression of textual and non-textual features is proposed. In order to provide visually impaired people with the opportunity to work in the cybersecurity field, we propose a method of analysing malware by ear.

***Keywords:*** audialization, malicious code, human-computer interaction, bisection.

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## Introduction

Information security is a huge research field due to ubiquitous digitalisation. One of the main risks of computer usage is threats related to malware spreading and network vulnerabilities. Organizations and individuals hold financial and reputational damage caused by various types of computer attacks, particularly by data leakage and ransomware infections.

The information security ecosystem includes antiviruses, firewalls, event management systems, vulnerability scanners for scanning files, network activity and evaluation of system behaviour. Vendors aim to automate information security products by implementing API and command-line interfaces which process textual data.

Nowadays, a lack of highly qualified specialists in the area of information security is observed (Fourie et al.,2014). On the one hand, this problem could be solved by involving college and university students, school pupils and other specialists without working experience (Mikhail et al., 2003). On the other, the involvement of disabled people could be a solution. However, this approach is used much less often (McDonnall & Crudden, 2015).

According to the World Health Organization, worldwide, in 2012, there were about 39 million blind people and 246 million people with poor eyesight ( World Health Organization, 2012). And in 2020, there were 33.6 million of complete blindness cases globally (Vision Loss Expert Group of the Global Burden of Disease Study, 2020). Currently, they are unable to work professionally in information security due to vision problems. But using sonificated tools, helping to detect malware could resolve the problem and increase workplaces. In these consequences, using audialization methods and techniques might be a solution.

Sonification techniques are used for expressing data using sound. They are vastly applied in various areas, from biomedicine to seismology, and they are based on methods of acoustics, computer science, linguistics, and music theory (Dorigo et al., 2013). The features of computer attacks could be sonified by the sequences of musical sounds, noises, and speech recordings.

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This is the reason why we consider that sonification is a key that will help visually impaired people work in cybersecurity.

This paper provides results of audialization of behavioural events, sources of computer attacks, sensor states of security sensors and the content language of the attack content.

In order to help the operator of an information security system to react efficiently to a computer attack we have encoded several features: the intensity of events, the danger degree, the novelty and source of the threat, the content language of the attack tools, the type of computer attack (malicious executable file or link to an infected website), the placement of elements in the list of features, the element number and the length of the signs list, arbitrary text strings. The composed sound interface is semantically significant for the operator of the information security system. In particular, the sensor state, the geographical location of the attack source, the attacker's language, and the tempo and type of attack were encoded by classical music fragments.

## Subject area overview

Sonification techniques are vastly used to facilitate computer access for blind and visually disabled people. For this purpose, relief-point displays and means of speech output were created. In this case, the text is voiced using screen access programs and sound synthesizers (Dorigo et al. 2013). Qualitative features are sonified by musical instruments with different timbres, and quantitative ones - with sounds of different frequencies and loudness. Such non-verbal audio interfaces use the sound of real-world objects, familiar audio signals and surrounding sound (Keller & Stevens, 2004; Frauenberger & Noisternig, 2003).

Musical sounds are characterized by a period of oscillation, a linear spectrum, as well as volume, pitch, and timbre (Hermann et al., 2011; Kuznecov, 1989). A person could perceive by ear the melody, rhythm, tonality, and timbre of the instrument, and recognize music style, the composer, as well as the emotional colouring (Bożena, 2005). The perception of mode and completed musical phrases is observed in detail in paper (Noll & Clampitt, 2019). The

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group theory in music is described in depth in the works (Berry & Fiore, 2016; Hughes, 2015). The group consists of twelve notes of each octave according to the transposition operation (Peck, 2015).

Neuro linguists have found a parallel between the perception of speech and music: the human brain reacts to a melody ending on a false note (not corresponding to the rules of musical harmony) in the same way as it reacts to syntactic and semantic errors in sentences (Christiane, 2017). We propose to use these parallels between the perception of sounds and behaviour to form the basis of an information security tool with an audio interface.

Scientific studies related to sonification of complex data structures and information security events have appeared in recent years. In 2019, researchers demonstrated musical encoding of authentication events over nine continuous months from an enterprise network (Falk, 2019). They have transformed computer network traffic into music using volume-centric approach and number-based approach. In 2021, spider web architectures were translated into musical sounds (Su, 2021). Spider webs are similar to computer networks in terms of structure, so the proposed method can be used for the sonification of network security characteristics. In 2021, a musical interface for network security monitor based on high-level parameters of Baroque music was developed (Cai, 2021).

As a result of solving text to speech transformation tasks, IT giants have developed speech synthesisers for various languages. But some malicious codes may contain text lines not supported by the existing speech synthesisers, e.g. hexadecimal sequences or phrases in rare dialects. So, the sound interface of a computer attack detector should be able to vocalize arbitrary texts in a form convenient for the operator. Also, the operator may get tired after listening to a large amount of synthesised speech. That is why some audition load optimization is required.

To the best of our knowledge, there is no information security application which allows to investigate and block computer attacks solely by hearing. Academic researchers propose sonification methods for security data vocalisation but only as additional to the visual user interface. So, we are planning to fill the gap in the research field by developing an information

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security solution which combines text vocalisation with various sounds to exclude the necessity of visual work.

The implemented version of the audio interface uses Web Speech API and the BASS software library, as it is free and has sufficient functionality to change the volume, overlay sound recordings and work with various audio file formats.

## Results

### Auditory expression of textual features

We have studied the applicability of the existing speech synthesisers for developing sonified interfaces for malware scanners and network attack detectors. The resulting sonified applications rely on the free JavaScript library Web Speech API for vocalisation of English text and on our custom speech synthesiser based on the BASS library (Web Speech API; BASS Audio Library). The web application fetches verdicts of antiviruses via Virustotal API and vocalizes the downloaded report by speech or music according to the mode chosen by pressing keyboard buttons. The client part of our application is written on React JS, which acquires Node JS server for the sound recordings

The proposed sonified desktop application connects to a website that checks intercepted files and network requests using malware analysis tools. In order to extract features of executable file, the analytical subsystem firstly determined its type by its content, and then launched console reverse engineering utilities. The file type, compiler and installer version were determined by the Detect-It-Easy console program. The details of the digital signature contained in the file were determined by the Sysinternals Suite programs. The Yara scanner was used to search for signatures, and the Radare 2 toolkit was used to search for the characteristics of executable files. The analytical subsystem unpacked office documents using the OfficeMalScanner program so that the operator could check the presence of embedded malicious code.

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At the top level of the menu, the operator is provided with a list of file or web page names to which the network requests have been registered. To go to the object features menu, the operator must press the “X” key. The keys “A”, “Z”, “Q”, “C”, “B”, and “M” are intended to scroll the list of objects, return to the top level of the list from the feature menu, and voice additional details depending on the type of observed object. These keys were chosen as their location is similar for the most popular keyboard layouts (QWERTY and COLEMAK).

Clicking “A”, “Z” keys in the features menu launch the analysis tools that extract the next or previous characteristics of the observed object. The output of the analysis tools is normalized to short text strings contained in the sound recording library. Table 1 contains an example of the normalization of the file type by the text output of the Detect-It-Easy utility. Firstly, the most significant feature is selected, then special characters, extra spaces and punctuation marks are removed from its text representation. After normalization, the string w remains; only this string should be voiced.

*Table 1. Normalization of file type*

| № | Features returned by Detect-It-Easy | Normalized result |
|---|---|---|
| 1 | PE: compiler: Microsoft Visual C++(2013)[msvcrt] | library-pe-qt |
| 2 | PE: library: Qt(5.6.3.0)[-] | |
| 3 | PE: linker: Microsoft Linker(12.0)[EXE32,console] | |

The collected features are played back by the audio recording via a JSON dictionary that contains a list of K keys as well as corresponding paths to audio files. String w corresponds to each normalized feature. If string w is entirely contained in the JSON dictionary of sound recordings, it would be played back. Otherwise, the substrings s_1,s_2…s_p, will be played back.

- **Step 1**. Initialize string w and list K.
- **Step 2**. Reset the countersi и j, initialize S as an empty set.
- **Step 3**. If i<n, go to Step 4, otherwise go to Step 9
- **Step 4**. If j<|K|, go to Step 5, otherwise go to Step 7
- **Step 5**. If substring w_i 〖…w〗_(i+|k_j | ) matches with k_j, add k_j to the set S.
- **Step 6**. Increment the counter j and go to Step 4
- **Step 7**. Append an empty character to each sequence from the set S.
- **Step 8**. Increment the counter i and go to Step 3
- **Step 9**. Select sequence s_(w,K) with the smallest number of empty characters from the set S.
- **Step 10.** Return founded sequence s_(w,K).

These substrings are used to decompose initial string according to the following algorithm, where i,j mean the character counter in the initial string and the counter in the list of K keys of the sound dictionary. The substrings s_(w,K) for the resulting sequence are stored in the set S during splitting process of the initial string.

The string corresponding to the normalized feature will be played back only if it is contained completely in the dictionary of sound recordings. Otherwise, the player voices the substrings into which the initial string has been divided. The result of the implementation of the proposed algorithm is the splitting of the voiced string into the smallest possible number of substrings so that they contain the maximum number of characters of the initial string. In this case, the auditory representation of the string would be euphonious.

## Navigating the feature list by ear

When launching the elaborated sonified information security tool, the operator hears the number of files that were collected. The operator can

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navigate through the list of files using the keyboard and play the list of extracted features. The proposed audio interface can sound the list of features line by line, or in larger parts to speed up the operator's work. The navigation process through the list of features by dividing it into equal parts is shown in Figure 1.

*Figure 1 Sonification of features bisection*


| | |
|---|---|
| Bkav | tehtris |
| Lionic | ESET-NOD32 |
| Elastic | Baidu |
| ClamAV | APEX |
| CMC | Avast |
| CAT-QuickHeal | Cynet |
| McAfee | Kaspersky |
| Malwarebytes | Alibaba |

If dangerous features are not observed in the list operator will hear a special sound signal 𝄞. If dangerous features are detected, the audio interface will represent them with sounds of different pitches so that each feature

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corresponds to one note of one of two chords of different pitches. The order of notes in ascending pitch corresponds to the order of features in ascending order of their numbers. For example, the combination of the first, second and fifth features corresponds to the consonance of the two lower sounds of the seventh chord in the small octave and the lower sound of the seventh chord in the first octave. The combination of the fourth and eighth features corresponds to the consonance of the upper sounds of both seventh chords.

Using the keyboard, the operator selects the number of parts p into which he is going to divide the list of features and the number of simultaneously sounding notes m that make up chords or consonances that he can distinguish. If the operator cannot distinguish not a single chord, the audio interface will reproduce the note of each feature separately. Otherwise, the audio interface will split the list of features into p parts, where $2 \leq p \leq 9, p \in N$, and then voice the placement of essential features in the resulting split using a chord, containing m notes.

Figure 1 displays the process of sonification of a list of 15 with only one dangerous feature at p=2. The audio interface splits the list of features into two parts. Then the first and second halves of the features are voiced in turn. The first half of the features is voiced by noise to show the absence of important data. Then the second half of the features is recursively divided into two equal parts, until the operator reaches the only one dangerous feature. The whole process requires the operator of the deceptive system to listen to 2·log_2^16=8 sound recordings, but does not require a musical ear, i.e. distinguishing notes. The time complexity of the searching process of an essential feature for a list of n elements is equal to

$$f(p) = p \cdot \lceil log_p n \rceil \quad (1)$$

If the operator has at least a slightly developed musical ear, and he is able to distinguish the consonances of two notes m=2, then the search process could be reduced by half due to the encoding of pairs of features. Instead of listening to the sound recording corresponding to the first and then the second half of the signs step by step. In this case, the operator immediately hears the consonance corresponding to one of the four variants of the presence of essential signs in each of the parts. The four possible variants are encoded

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using the consonance D-d1,D,d1,⸸, where ⸸ denotes the absence of essential features.

The maximum number of consonances that the interface offers to remember is 256. These consonances include all combinations of notes from the 7th chord in the small octave and the seventh chord in the first octave. The time complexity when encoding combinations of features using consonances is equal to

$$f(m,p) = \left\lceil \frac{p}{m} \right\rceil \cdot \lceil log_p\, n \rceil \qquad (2)$$

Let us calculate the complexity of searching for a dangerous feature by the audio interface, depending on the number of simultaneously sounding notes from two seventh chords that the operator is able to distinguish.

Statement 1. For any fixed number of parts p, into which the list of features is divided, the minimum time complexity is achieved when the number of simultaneously sounding notes m is equal to p.

Proof. Let m_1<p<m_2. As p,m_1,m_2∈N, for a smaller number of notes, the following inequality is true ⌈p/m_1 ⌉≥1, and for a larger number of notes, right ⌈p/m_2 ⌉=1. Therefore,

$$f(m_1,p) = \left\lceil \frac{p}{m_1} \right\rceil \cdot \lceil log_p\, n \rceil > \lceil log_p\, n \rceil = f(m_2,p) \qquad (3)$$

Thus, for a fixed p and m<p, the time complexity function is equal to a constant less than any value of the same function for m>p, qed.

Statement 2. For any fixed number of simultaneously sounding notes m, the minimum time complexity is achieved when the number of parts p into which the list of features is divided is equal to m.

Proof. For any p_1<m, p_1∈N the following inequality is true

$$f(m,p_1) = \left\lceil \frac{p_1}{m} \right\rceil \cdot \lceil log_{p_1}\, n \rceil = \lceil log_{p_1}\, n \rceil > \lceil log_m\, n \rceil = f(m,m) \qquad (4)$$

Consider the case when p_2>m, p_2∈N.

$$f(m,p_2) = \left\lceil \frac{p_2}{m} \right\rceil \cdot \left\lceil \frac{ln\, n}{ln\, p_2} \right\rceil > \frac{p_2}{m} \cdot \frac{ln\, n}{ln\, p_2} \qquad (5)$$

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$$f'_{p_2}(m, p_2) = \left\lceil \frac{1}{m} \right\rceil \cdot \left\lceil \frac{ln\, n}{ln\, p_2} \right\rceil - \left\lceil \frac{p_2}{m} \right\rceil \cdot \left\lceil \frac{ln\, n}{p_2 (ln\, p_2)^2} \right\rceil \quad (6)$$

$$f'_{p_2}(m, p_2) > \frac{1}{m} \cdot \frac{ln\, n}{ln\, p_2} - \frac{ln\, n}{m(ln\, p_2)^2} > 0 \quad (7)$$

The time complexity increases monotonically when p_2>m, so

$$f(m, p_2) > f(m, m) \quad (8)$$

Therefore, the minimum value of the complexity function is achieved when p=m, qed.

Consequence 1. With an optimal choice of the number of sounding not es and the splitting power, the time complexity is equal to

$$f(m) = \lceil log_m\, n \rceil \quad (9)$$

We could come to the conclusion that to navigate through the list of 32 elements, an operator who distinguishes only 2 notes will be able to detect the essential feature in 5 iterations, an operator who distinguishes 4 notes – in 3 iterations, and those with a better musical ear – in 2 iterations.

## Event flow sonification

The proposed audio interface encodes previously known computer attacks by music and unknown computer attacks by noise. A certain plot of the musical fragment corresponds to the certain type of computer attack. For example, sending a file to a virtual user is expressed by a dramatic musical fragment in which one of the characters directly harms another. The transfer of a link is musically expressed by a plot in which one character harms another character indirectly.

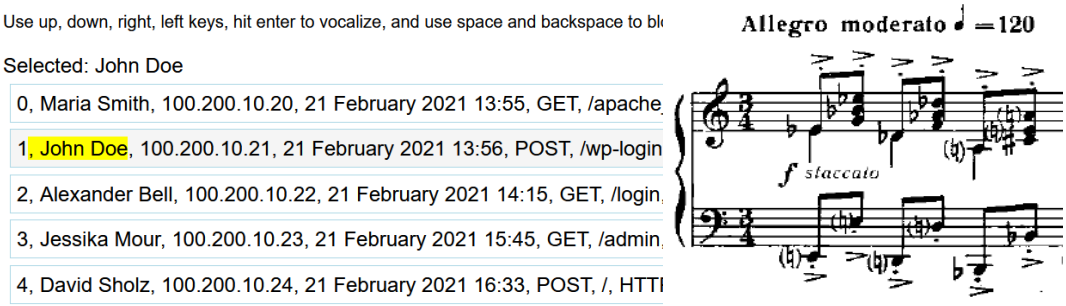
If it is possible to recognize the attacker's language, the audio interface will play back a vocal music characteristic for the country which is the origin of the computer attack. Excerpts from classical music were used for playing back recordings. The sounds of nature were divided into two groups: those that express dangerous and safe situations for humans and were grouped by noise intensity. Musical sound recordings also were grouped according to the plot, emotional colouring and tempo of the sound.

To simulate the attacking process and check the efficiency of the proposed audio interface, we have formed a list of sound recordings that express the flow of actions of the attackers who penetrated the website from the Commonwealth of Independent States (CIS) formed of nine post-Sovetic republics. It is presented in Table 1. It is assumed that the operator will associate the noise and music with the CIS region's nature or culture.

In order to express the intensity of the event flow, the sources of computer attacks, the harmfulness of the attacker's actions and the novelty of the means of computer attacks, a collection of sound recordings were created. This collection includes sounds of nature from various world regions and fragments of musical compositions.

Musical compositions differ in tempo and time signature. Tempo is set by the number of beats per minute z and their duration. The alternation of down and up beats in a bar is determined by the size (x¦y) – two natural numerals x,y∈N, where x,y>1, for example (2/4) – two quarters. The lower numeral of the size is a multiple of two and means the duration of the beat, which is uniquely determined by the tempo. The upper numeral indicates the number of beats per bar. For example, in Figure 2, the size is (3/4), and the tempo is 120 quarter fractions per minute.

*Figure 2 An excerpt from the opera associated with a row of network attack description table*




The time signature is recognized as simple if x=2 or x=3. If x=2a or x=3b, where a,b∈N time signature is recognized as complex. In all other cases, time signature is recognized as mixed (when x=2a+3b, where x>1,x∈N). There is one downbeat per one bar in simple time signature. In complex time signature there is x/3 downbeat per x/2 bar, depending if x multiple of 2 or 3. In mixed time signature, there are exactly a+b downbeats.

The operator distinguishes by ear downbeats – strongest accents. The frequency of the downbeats could be calculated by the time signature and tempo of the music.

$$\boldsymbol{\nu(x,y,z) = \frac{1}{60z} \cdot \frac{a+b}{2a+3b}} \quad (10)$$

The number of downbeats, which will sound per a minute at a constant time signature and tempo of the music is equal to:

$$\boldsymbol{\lambda(x,y,z) = \frac{60}{\nu(x,y,z)} = z \cdot \frac{a+b}{2a+3b}} \quad (11)$$

To correspond the music with a certain frequency of downbeats with attacker's behaviour, we have selected the timeline scale and defined each unit of the timeline during which the violator presented any action. The maximum frequency of the attacker´s actions within the scale of the timeline is considered the tempo of its behaviour. In order to measure it is necessary to define two attackers' actions separated by a minimum time interval Δt.

$$\boldsymbol{\lambda_{behaviour}(\Delta t) = 60 \cdot \frac{1}{\Delta t}} \quad (12)$$

If the minimum time between the attacker's actions equals to 1 second, we will correspond the attacker's behaviour with music with frequency of downbeats equal to 1HZ or 60 downbeats per minute.

The emotional colouring of the music was used to encode the state of the sensors with which the attacker interacted. Melodies with national motifs corresponded to the geographical location of the sources of computer attacks.

Geospatial data helps to recognise the origins and targets of computer attack. Commonly advanced persistent threats are separated from regular computer attacks by country and nationality which victim belongs to. The novelty of the means of computer attack was encoded by applying noise to music. The more clearly the music is heard, the higher is the share of events that triggered signatures in comparison with the share of new unknown events that characterize the means of computer attack. Various noises help to express the intensity, harmfulness and source of each computer attack. For a flow of known events, we have identified two types of a tense state of honeypot: site

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hacking and transfer of a link or file. For each type of tense state we have determined a certain musical fragment.

*Table 1 Sound recordings compared to attackers from CIS*

| Type of event flow | No suspicious actions | Detected hacking actions | Detected malware transferring |
|---|---|---|---|
| Weak flow of unknown events | Forest sound | Avalanche noise | Avalanche noise |
| A weak flow of know events | An overture from the ballet "Anyuta" | A scene from the ballet "Anyuta" before tarantella | The duel scene from the opera "Eugene Onegin "(without vocals) |
| A weak flow of known events and the language of attacker is known | Overture from the opera "Eugene Onegin" | Lisa's aria from the opera "The Queen of Spades" | Tomsky's aria from the opera" The Queen of Spades " |
| A strong flow of unknown events | Sound of wind in the forest | The sound of a blizzard | The sound of a blizzard |
| A strong flow of known events | Russian dance from the ballet "Swan Lake" | Odile scene from the ballet "Swan Lake" | Shostakovich's Leningrad Symphony |
| A strong flow of known events and the language of attacker is known | Chorus of peasants from the opera "Eugene Onegin" | Aria of Tomsky from the opera "The Queen of Spades" | A riot scene from the opera "Boris Godunov" |

Table 2 represents the names of musical fragments associated with attackers with the location in the Middle East.

*Table 2 Sound recordings compared to attackers from the Middle East*

| Type of event flow | No suspicious actions | Detected hacking actions | Detected malware transferring |
|---|---|---|---|
| Weak flow of unknown events | Desert fauna sound | Bee flying | Bee flying |

| Type of event flow | No suspicious actions | Detected hacking actions | Detected malware transferring |
|---|---|---|---|
| A weak flow of know events | Unhurried cheerful Arabic music | Unhurried dramatic Arabic music | The scene of the murder of Vaclav from the ballet “The Fountain of Bakhchisarai” |
| A weak flow of known events and the language of the attacker is known | A slow cheerful Arabic song | Slow aria of the Shamakhan Queen from the opera “The Golden Cockerel” | Aria of the Turkish Sultan after the castle storming from the opera “Mahomet the Second” |
| A strong flow of unknown events | The sound horse galloping leisurely | Sandstorm sound | Sandstorm sound |
| A strong flow of known events | Fast fun Arabic music | Polovtsian dances from the opera “Prince Igor” | The scene of the palace capture by the Tatars from the ballet “The Fountain of Bakhchisarai” |
| A strong flow of known events and the language of attacker is known | Fast fun Arabic song | A quick aria of the Shamakhan Queen from the opera “The Golden | The scene of the capture of a Greek city from the opera “Mahomet the Second” |

## Discussion

The sound interface for information security solutions is still in the development stage. Therefore, the most frequent questions are related to the properties of music and the formal model used to design the auditory display. So, we are planning to use all easy to perceive characteristics of music like intonation and tempo. Also, we have proposed a mathematical approach base on game-theoretical modelling to encode information security events into musical pieces (Vishnevsky, 2022).

The usage of music volume was recognized as ineffective for continuous data signal where minor changes are significant (Falk, 2019). The macrostructure and high-level patterns of music are much more easily to identify for non-musicians than the pitches (Cai, 2021). So it makes sense to develop sound interfaces adaptable to the musical ear of the user.

## Conclusions

In this study we have proposed and implemented a method of encoding information security events using plots of musical pieces, a method of verdicts lists musical sonification, and an algorithm for arbitrary text synthesis. Our initial prototype was written in C++, but we are redeveloping our sonified application in JavaScript to make it possible to work on various types of electronic devices. The created prototype opens the possibility of professional work for the visually impaired in the field of information security and adapts the complexity of detecting computer attacks to the musical ear of the security operator.

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# CURB RAMP AND ACCESSIBILITY ELEMENT UPGRADE PRIORITIZATION: A LITERATURE REVIEW AND ANALYSIS OF MULTI-STATE SURVEY DATA

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Abstract: Curb ramps are a universally beneficial element of the built environment, providing improved access for all users. The Americans with Disabilities Act (ADA) requires compliant ramps to be installed with new construction or when a facility is altered. The large quantity of ramps and other facilities that must be upgraded to achieve full compliance, coupled with limited budgets, often requires states to prioritize ramps for retrofit over time. Users with varying disabilities might prioritize curb ramp improvements differently. This study assessed the state of the practice for prioritizing curb ramp upgrades and retrofits. A background review of national standards and guidance related to curb ramps was conducted. Prioritization processes for similar accessibility elements, including sidewalks and accessible pedestrian signals, were gathered through a literature review. State representatives were contacted through an email survey to identify existing prioritization processes for curb ramps. Americans with Disabilities Act Accessibility Guidelines and Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way provide similar standards and guidelines for accessibility. Three studies found that pedestrians with vision disabilities found domed surfaces most detectable, although users with mobility disabilities experienced negative safety and negotiability impacts with detectable warning surfaces. Compliance with accessibility standards and citizen requests were most commonly used for prioritization at the state level; localities were more likely to consider proximity to pedestrian generators and transit. These findings provide a foundational

resource for agencies developing or revising prioritization processes for curb ramp retrofits.

***Keywords:*** barrier-free design, pedestrian areas, persons with disabilities, retrofitting, strategic planning.

## Introduction

Curb ramps are universally beneficial; it is not only people with disabilities who have improved access when curb ramps are implemented. People with strollers, carts, luggage, and runners and pedestrians enjoy improved access with curb ramps. A study of pedestrians in Sarasota, Florida, showed that nine out of 10 "unencumbered pedestrians" at a shopping mall went out of their way to use a curb ramp (Blackwell, 2017). Though small compared to some large-scale transportation projects, curb ramps play a large role in making transportation facilities available and accessible for all users.

Title II of the Americans with Disabilities Act (ADA) outlines requirements for existing and new facilities operated by a public entity (U.S. Department of Justice, 2010b). The ADA also requires public entities with over 50 employees to develop an ADA Transition Plan. The plan should contain a list of physical barriers in the entity's facilities, a detailed description of how the barriers will be removed, and a schedule for taking necessary steps towards compliance. Subpart D of Title II of the ADA provides specific requirements for improving facilities and becoming compliant (U.S. Department of Justice, 2010b). For facilities that were previously compliant with the 1991 ADA Standards for Accessible Design, there is no requirement to be compliant with the 2010 ADA Standards for Accessible Design until the facility is altered, at which point it must comply with 2010 standards. If strict compliance with the standards is not feasible, the maximum level of compliance possible should be achieved. If a new facility is constructed, it should be accessible by 2010 standards.

From the perspective of a person who has a disability, a missing curb ramp is essentially a missing link in the sidewalk network. However, people with different sorts of disabilities might prioritize improvements differently. For example, although a wheelchair user might prefer any ramp over no ramp,

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someone who is blind but ambulatory might prefer a curb without a ramp over a curb ramp without truncated domes because the curb is cane-detectable. The large quantity of ramps and other facilities that must be upgraded to achieve full ADA compliance, coupled with limited budgets, often requires states to prioritize ramps for retrofit over time.

## Methodology

A background review of standards and guidance related to curb ramps was undertaken to obtain relevant information regarding ADA guidelines and requirements, including ADA Accessibility Guidelines and Public Right-of-Way Accessibility Guidelines.

A literature review was undertaken to obtain relevant information regarding curb ramps. This review included studies of how people with visual and mobility impairments interact with curb ramps and studies of prioritization processes for similar facilities such as sidewalks and accessible pedestrian signals.

State DOTs and localities have developed various approaches to create prioritization processes based on curb ramp inventories included in their ADA transition plans. Representatives of all 50 state DOTs and the District of Columbia DOT were contacted through the AASHTO Research Advisory Committee to assess what methods other states were using to prioritize curb ramp retrofits.

Because no research studies directly addressing the curb ramp prioritization process were found, ADA transition plans were reviewed for several counties, cities, and towns to identify examples of priorities each entity incorporated into its process. The search for ADA transition plans was conducted to find a diverse selection of localities, geographically and by population size. Transition plans that did not include a curb ramp prioritization process were excluded.

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# Results

## Background Review of Standards and Guidance

National standards and guidance related to curb ramps were reviewed. Two sets of design guidelines exist at the federal level for implementing accessibility requirements: the ADA Accessibility Guidelines (ADAAG) (United States Access Board, 2004) and the Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way (PROWAG) (United States Access Board, 2011).

### *ADA Accessibility Guidelines*

The ADA of 1990 prohibits discrimination against individuals with disabilities. Title II of the ADA applies specifically to state and local government programs and services, with different requirements for existing and new facilities (U.S. Department of Justice, 2010b). ADAAG outlines specific requirements for designing buildings and facilities to comply with the ADA and is the basis for the regulations enforced by the U.S. Departments of Justice and Transportation (United States Access Board, 2004). ADAAG was first published in 1991 and was the foundation for the 1991 ADA Standards for Accessible Design. An updated ADAAG was published in 2004 and was adopted as part of the 2010 ADA Standards for Accessible Design (U.S. Department of Justice, 2010a). ADAAG contains specifications for curb ramps, including running, cross, and counter slopes; flared sides; width; and landings.

### *Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way*

PROWAG (United States Access Board, 2011) has been adopted as a set of design standards by many localities and state DOTs, but the federal government has not yet adopted them as enforceable standards. Like ADAAG, PROWAG covers curb ramps and many other elements in the public right of way, such as accessible pedestrian signals, street furniture, and on-street parking. Specifications for curb ramps in PROWAG relate to running, cross, and counter slopes; flared sides; width; and turning space. Table 1 shows the design guidelines for curb ramps outlined in PROWAG vs ADAAG.

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*Table 1. PROWAG vs ADAAG Physical Specifications for Curb Ramps.*

| Element | ADAAG Specification | PROWAG Specification |
|---|---|---|
| Location | Provided wherever an accessible route crosses a curb | *Shall connect the pedestrian access routes at each pedestrian street crossing*[a] |
| Running Slope | 1:12 (8.3%) maximum | 5% minimum, 8.3% maximum |
| Cross Slope | 1:48 (2.1%) maximum | 2% maximum |
| Clear Width | 36 in minimum | *1.2 m (48 in) minimum* |
| Surface | Firm, stable, and slip resistant | Firm, stable, and slip resistant |
| Sides of Curb Ramps | Flared sides 1:10 (10%) maximum slope | Flared sides 10% maximum slope |
| Top Landing | Minimum 36 in clear length, clear width at least as wide as ramp, excluding flared sides | *Minimum 1.2 m (4 ft) x 1.2 m (4 ft) Running slope not greater than 2%* |
| Counter Slope | 1:20 (5%) maximum | 5% maximum |
| Clear Space | 4 ft x 4 ft within marked crossings, if present, and outside of active traffic lanes[b] | 1.2 m (4 ft) x 1.2 m (4 ft) within the width of the pedestrian street crossing and wholly outside of the parallel vehicle travel lane |

ADAAG = Americans with Disabilities Act Accessibility Guidelines; PROWAG = Proposed Accessibility Guidelines for Pedestrian Facilities in the Public Right-of-Way.
[a] Specifications that are different across ADAAG and PROWAG are in italics
[b] Only specified for diagonal curb ramps

## Literature Review

The literature review results cover a range of topics related to curb ramps, including how people with visual and mobility impairments interact with curb

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ramps and prioritization processes for sidewalks and accessible pedestrian signals (APS).

### *How People with Disabilities Interact With Curb Ramps*

Much of the research surrounding curb ramps have focused on the effectiveness of detectable warning surfaces (DWSs) and how people with visual and mobility impairments interact with different surface types. Four studies were reviewed. One looked at the built environment and barriers for adults with mobility disabilities, and three analyzed the detectability and negotiability of DWSs and the perception of these surfaces by people with visual and mobility impairments. These interactions could inform the design of a prioritization process for curb ramp improvements.

**Barriers in the Built Environment.** A study performed in King County, Washington, involved 35 participants over age 50 who used assistive mobility devices (Rosenberg, Huang, Simonovich, & Belza, 2013). Participants wore a GPS tracking device for three days and then were interviewed about their built environments, particularly about trips recorded via GPS. Participants frequently noted that curb ramps were often only on one side of the road or were not present at all crossings along the sidewalk, resulting in them having to travel on the road until curb ramps were available. The condition of curb ramps was also important; broken or steep ramps were avoided. Some participants indicated that the DWS was helpful but also slippery when wet. Overall, interviewees agreed that the presence of curb ramps promoted mobility.

**Detectable Warning Surfaces.** The Federal Transit Administration published a study in 1994 evaluating DWSs for detectability by visually impaired users and negotiability by physically impaired users (Bentzen, Nolin, Easton, Desmarais, & Mitchell, 1994).

In that study, blind participants tested 13 DWSs, which varied in dome size and spacing, for detectability underfoot. The 12 commercially available options were detected underfoot in at least 95% of the trials; a surface that was not commercially available was only detected in 88% of the trials. The study concluded that DWSs with a range of dome sizes and spacings varying from ADAAG specifications could still be highly detectable. Four of the surfaces, representing

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extreme cases of detectability, were tested again for detectability with a cane. Three surfaces were detected in 100% of the trials; the remaining surface was detected in 98% of trials. It was concluded that surfaces readily detectable underfoot are also readily detectable by users with a long cane.

Forty participants with physical disabilities tested the relative safety and negotiability of 9 detectable surfaces compared to a brushed concrete ramp. Participants used a variety of mobility aids; 7 participants did not use an aid. The surfaces with small, widely spaced, horizontally and vertically aligned domes resulted in the fewest difficulties for those using travel aids. In addition, users of wheeled devices experienced fewer cases of wheel entrapment with horizontally and vertically aligned domes than with diagonally aligned domes. Given the negative impact on safety and negotiability experienced by physically disabled users, the authors recommended that the installed DWS (surface with truncated domes) should be limited in width to no more than required for visually impaired users.

A 1995 study tested 7 DWSs of varying materials for detectability and negotiability (O'Leary, Lockwood, Taylor, & Lavely, 1995). Fifty-two participants with visual impairments tested the detectability of the surfaces. Most used a cane, guide dog, or sighted guide; some used multiple aids, while others did not use an aid at all. Participants found domed surfaces far more detectable than aggregate surfaces. Participants most often identified black concrete and yellow composite domes as "very easy" or "easy" to detect.

In that study, six participants with mobility impairments tested the same 7 DWSs for negotiability using their mobility aids (wheelchairs, crutches, canes, or human assistants). Domed surfaces were least preferred, and some participants indicated that they would avoid any domed surfaces when travelling. All participants indicated that lateral domes (corduroy) made movement unstable, and aggregate surfaces were the easiest to manoeuvre.

Another study looked at the impact of truncated dome detectable warnings on travellers using wheelchairs (Lee, 2011). Twenty-one participants, using either a manual or a power wheelchair, rated the safety and negotiability of 3 ramps: one with no DWS, one with squarely aligned domes, and one with diagonally aligned domes. Preferences of manual wheelchair users were split between squarely

aligned truncated domes and ramps without domes. Power wheelchair users had a strong preference for the ramp without domes. Diagonal domes were least preferred by more than half of the participants. A statistically significant increase in effort was observed when manual wheelchair users went up ramps with diagonally aligned domes compared to ramps with squarely aligned domes.

In summary, literature on how people with disabilities interact with curb ramps confirmed that people with different sorts of disabilities might prioritize improvements differently. Three studies found that although adding domed surfaces to curb ramps was beneficial or even critical for pedestrians with visual impairments, it could be detrimental to ramp negotiability and manoeuvrability for pedestrians with mobility impairments. At the same time, installation details can matter: trials that compared squarely-aligned domes and diagonally-aligned domes emphasized the importance of using squarely-aligned domes for negotiability with wheeled mobility aids. The absence of curb ramps in good condition at all crossings along a route creates a gap in the network for people with limited mobility.

In the years since these studies were conducted, there have been many technological innovations, such as smart canes and apps, that assist travellers with disabilities. That being said, the authors know of no research that suggests that the way people with disabilities interact with the physical features of curb ramps has changed markedly in the intervening years.

### *Prioritization Processes*

Although no studies were found that directly addressed prioritization processes for curb ramp improvements, researchers identified studies of, summaries of, and tools for prioritization processes for related pedestrian infrastructure elements: sidewalks and APS.

**Sidewalk Prioritization Processes.** Five prioritization processes for sidewalks were reviewed. Each uses different methods to determine which sidewalk segments should be improved first. The methods use a wide range of data sources, from generalized information about a site to specific data collected for the prioritization process.

In 2013, researchers at Georgia Tech collected sidewalk quality data around the City of Atlanta's Midtown neighbourhood using an automated tablet-based system they developed through an Android™ app, Sidewalk Sentry™ (Frackelton, 2013). The app collected GPS-enabled video data as well as information from the accelerometer and gyroscope in the tablet, which was attached to a manual wheelchair. Student researchers and community volunteers recorded sidewalk data for an area covering over 659 roadway miles. A weighted ranking system was proposed in which the data from the app would be combined with pedestrian activity data and demographic data to prioritize projects based on a pedestrian potential index (PPI) and a pedestrian deficiency index (PDI). The PPI assessed variables including pedestrian activity, population density, and transportation mode share. The PDI included sidewalk width and pedestrian crash density. This method eliminated sidewalk-width data points that represented "no sidewalk"; the author indicated that future analyses should include absent sidewalks, which could improve the accuracy of the prioritization.

Another Georgia Tech app, Sidewalk Scout™, allowed users to input measurements of sidewalks, curb ramps, bus stops, and crosswalks (Boyer, Walls, Dyess, Greenwald, & Guensler, 2018). Raw data from Sidewalk Scout™ and Sidewalk Sentry™ were aggregated in GIS and assigned to sidewalk segments using a semi-automated process. The sidewalk asset management system compared raw sidewalk data with ADAAG requirements to determine compliance for each element. The researchers developed a Sidewalk Prioritization Index (SPI) that prioritized sidewalk links across three categories: safety, mobility, and accessibility. Each category was further broken down into factors such as locations of pedestrian injury, employment district, and presence of an obstruction in the sidewalk. These factors were then weighted based on input from over 1,000 survey respondents to reflect community interests accurately. Final rankings were determined by summing the scores for each factor within each of the three categories and averaging the category scores. The final score for each sidewalk segment was ranked to determine which segments should be the highest priority.

The City of Falls Church, Virginia, created a sidewalk prioritization process that required data about the surrounding area and the physical condition of the

sidewalks (City of Falls Church, 2012). The city identified five priority areas in which to categorize the sidewalks:

- Public input requests
- Sidewalks along transit routes and primary routes to Metrorail stations
- Sidewalks in commercial corridors
- Sidewalks along primary and secondary safe routes to schools and the park connectivity plan
- All other sidewalks

Within each of the five priority areas, the sidewalks were ranked based on an ADA compliance score, the number of obstacles along the segment, and the number of noncompliant driveways within the segment. The ADA compliance score was calculated as the length of deficiencies on the sidewalk segment (measured in feet), divided by the length of the sidewalk segment (measured in feet).

Deficiencies were determined based on variances from ADAAG requirements. The final score used to rank the sidewalks was calculated by summing the compliance score and the scores determined from Table 2, based on the characteristics of each sidewalk segment.

*Table 2. Point System for Ranking Sidewalk Projects, City of Falls Church, Virginia.*

| Criteria | Score | Measurement |
|---|---|---|
| Obstacles | 10 | Every obstacle that reduces sidewalk width to <36in |
| Driveways | 20 | 5 or more noncompliant driveways[a] |
| | 10 | 3-4 noncompliant driveways |
| | 5 | 1-2 noncompliant driveways |

[a] A noncompliant driveway was characterized by a sidewalk with a cross-slope greater than 2 percent

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The City's Transition Plan (City of Falls Church, 2012) indicated that the scores were used as guidance for developing a repair schedule. The Plan encouraged the repair of entire lengths of a given street rather than upgrading individual segments that may not create a continuous accessible path.

The City of Charlotte, North Carolina, had a sidewalk prioritization method in its 2017 Charlotte WALKS: Pedestrian Plan (City of Charlotte Department of Transportation, 2017). Eligible sidewalk projects were ranked based on proximity to pedestrian traffic generators, safety factors, connectivity with other sidewalks, cost, and proximity to disadvantaged populations. Ranking criteria and point values could be changed over time, resulting in the reprioritization of the projects. Sidewalk projects that presented unique circumstances, such as high traffic volumes or speeds, accessibility to transit, or pedestrian safety concerns, could be exempted from the ranking process altogether and moved to the top of the priority list.

Using the Absent Sidewalk Prioritization Model (Anderson, 2018), a study prioritized 2,349 miles of missing sidewalks in San Antonio, Texas. This model used four indices that were developed with input from a focus group: a Policy Score, a Demographic Score, a Pedestrian Attractor Score, and a Pedestrian Safety/Health Score. These four indices, taken together, encompassed a total of 27 criteria. The Policy Score was comprised of two binary elements: location of the missing sidewalk within Regional Centers (areas targeted for improvement to facilitate the rapid growth of the city) and within Corridors (major connections between the Regional Centers) (City of San Antonio, n.d.). The Demographic Score included elements such as residential population density, median household income, and the number of persons with disabilities. The Pedestrian Attractor Score included the proximity to schools, parks, government offices, healthcare facilities, and retail establishments. The Pedestrian Safety/Health Score captured pedestrian crashes and injuries and the street's functional classification. Each index was weighted equally in determining the final score for each sidewalk segment, which was used for prioritization. The author suggested that a future model could incorporate a gap analysis scoring sidewalk segments based on the length of continuous sidewalk that would result if constructed.

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Thus, several U.S. examples of sidewalk prioritization processes have been developed to support decisions regarding improvements when funds are limited. Each process employed a unique combination of sidewalk characteristics, including ADA compliance, adjacent land uses, and pedestrian crashes. Several methods used spatial data, such as population density or proximity to employment areas. Although the specifics of these prioritization processes differed, as would be expected given differences in local budgetary, political, and physical constraints, they all classified data elements into categories (variously named indices, priority areas, and ranking factors) to recognize the importance of accounting for multiple criteria in determining priorities for sidewalk construction and improvement. These efforts could be mirrored in the development of a curb ramp prioritization process, as similar data would inform the need for curb ramps, which would also benefit from prioritization based on multiple categories of data.

**APS Prioritization Processes.** Two methods were reviewed that provided processes for prioritizing the installation of APS.

In 2003, VDOT published guidelines developed for its Northern Virginia District in response to a request for APS at an intersection in Falls Church (Arnold & Dougald, 2003). These guidelines were established with guidance from VDOT, FHWA, the Virginia Department for the Blind and Visually Impaired, and the blind/visually impaired community. When evaluated, intersections were assigned points based on the following characteristics:

- Configuration of intersection
- Width of crossing
- Posted speed limit on the street to be crossed
- Heavy right-turn volumes that affect crossing
- Free flow right-turn lane that affects crossing
- Leading or exclusive pedestrian phases; mid-block exclusive pedestrian signals
- Proximity of intersection to pedestrian generators or attractors
- Requesting party's need is related to work or school
- Length of time intersection has been waiting for funding
- Other special traffic and mobility conditions

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Six of the characteristics were binary and awarded points for the presence of that element. The remaining points were assigned based on the crossing width, posted speed limit, proximity to pedestrian attractors, and time in queue. The sum of all of these scores could be used to prioritize crossings for a given fiscal year or a long-range plan.

In 2007, NCHRP published the APS Prioritization Tool, which uses observable characteristics of individual crosswalks and intersections to determine the crossing difficulty for blind pedestrians (Harkey, Carter, Barlow, & Bentzen, 2007). Scores calculated with this tool can be ranked, with the highest score representing the highest priority, to determine where investment in APS should be made or prioritize funding allocations for a given year. An intersection is evaluated and assigned tiered point values based on the following characteristics:

- Type of intersection
- Type of signalization
- Proximity to transit
- Proximity to facility for visually impaired, including libraries, schools, and rehabilitation centres for the blind
- Distance to major pedestrian attraction

The scores for each factor are summed to determine the score for an intersection. After scoring the intersection, each crosswalk is evaluated individually. Crosswalks are evaluated and assigned tiered point values based on the following characteristics:

- Crosswalk width
- Speed limit
- Crosswalk geometry
- Pedestrian signal control
- Vehicle signal control
- Off-peak traffic presence
- Distance to alternative APS crossing
- Location of pedestrian pushbutton
- Requests for APS

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Unlike intersection scoring, factors for crosswalk geometry, pedestrian signal control, vehicle signal control, and the pedestrian pushbutton location can have multiple selections. The crosswalk score is determined by summing the points assigned for each factor. The intersection score is added to the crossing score to determine the total crosswalk score, resulting in a score that accounts for the characteristics of both the crosswalk and the intersection. This tool was designed to evaluate an individual crosswalk rather than an entire intersection, as rating the intersection as a whole could dilute the score for the most critical crossing, resulting in inaccurate prioritization.

As with sidewalk prioritization processes, both of these prioritization processes for APS employ multiple evaluation criteria, from the physical characteristics of the facility in question to its proximity to various destinations. Because curb ramps, like APS, are typically located at intersections, the intersection-specific criteria present in APS prioritization processes may be particularly transferable to developing a prioritization process for curb ramps.

**Limitations.** Although curb ramps are an integral component of pedestrian infrastructure, none of the reviewed studies directly addressed the prioritization of curb ramp improvements. The research regarding curb ramps has primarily been focused on the detectability and negotiability of DWSs. Most of the studies focused on one user group, people with vision impairments or mobility impairments. A prioritization process would need to balance the various findings in the literature to account for all users.

All of the existing studies regarding prioritization processes focus on sidewalks or APS. Although each component is important, it is vital for a prioritization process to consider the entire pedestrian network and a pedestrian's interactions with each feature. A curb ramp prioritization process should also consider the impact of sidewalks and APS on the usability of the pedestrian network. This paper synthesizes all relevant information needed to inform a curb ramp prioritization process.

## Information From Other States

Prioritization processes for curb ramps have been developed at the state and local levels.

## *Curb Ramp Prioritization Processes at State DOTs*

The following question was distributed to state DOTs via the AASHTO Research Advisory Committee:

> What factors does your state consider when deciding which ramps to retrofit in a given year? (Examples include citizen requests, ramp condition, proximity to transit, etc.)

Fourteen states responded to the email survey. Seven states did not indicate a specific process for prioritizing curb ramp upgrades outside of planned paving projects. However, three of those states—Delaware, New Jersey, and Vermont—indicated that they prioritized citizen requests when received. Virginia's prioritization process was also reviewed (VDOT, 2019).

The criteria used for prioritization by responding states are shown in Table 3. Requests and ramp condition/compliance were the most frequently used prioritization criteria. 67% of all responding states considered citizen requests a high priority for improvement, and 47% incorporated condition/compliance data. Connectivity was only employed by states that have smaller state-maintained highway systems.

*Table 3. Prioritization Criteria for Curb Ramps Reported By State DOTs.*

| State | Requests | Condition/ Compliance | Demand/ Pedestrian Generators | Transit | Connectivity |
|---|---|---|---|---|---|
| Illinois | Y | Y | Y | N | N |
| Maine | Y | Y | N | Y | Y |
| Massachusetts | Y | N | Y | Y | Y |
| Montana | Y | Y | Y | N | N |
| New Hampshire | Y | Y | N | N | N |
| South Carolina | Y | Y | Y | Y | N |
| South Dakota | N | Y | Y | N | N |
| Virginia | Y | Y | N | N | N |

Y = State reported using the criterion; N = State did not report using the criterion

## *Curb Ramp Prioritization Processes in Counties, Cities, and Towns*

Three county-level ADA transition plans were reviewed. All three plans introduced a prioritization process based on both the physical condition of the curb ramps as well as the characteristics of the ramp location. Two of the counties—Ada County, Idaho, and San Francisco County, California—utilized a matrix system that placed ramps in prioritized categories based on a combination of location and condition factors. Sacramento County implemented scoring that incorporated a rating of expected pedestrian use and an assessment of the ramp's relative compliance with state and federal standards. The criteria used for prioritization by each county are shown in Table 4.

*Table 4. Prioritization Criteria for Curb Ramps Reported By Counties.*

| County | Requests | Condition/Compliance | Demand/ Pedestrian Generators | Transit | Connectivity |
|---|---|---|---|---|---|
| Ada County, Idaho | Y | Y | Y | Y | N |
| San Francisco County, California | Y | Y | Y | Y | N |
| Sacramento County, California | Y | Y | Y | Y | N |

Y = Country reported using the criterion; N = Country did not report using the criterion

Twelve ADA transition plans were reviewed for cities and towns around the United States. Each city and town had a unique prioritization process; however, several common methods were used. Four cities and one town used a scoring system, assigning points for traits that a ramp did or did not possess, including location and condition. Five cities utilized fixed categories to prioritize ramps. Categories were considered high, medium, or low priority and were associated with certain characteristics of ramps. Ramps were sorted into categories to determine priority. Redmond, Oregon, developed a prioritization matrix

combining both location and condition information to prioritize ramps (MIG, Inc., 2017). Frisco, Texas, used a system of both categories and scores to create a priority list for curb ramp upgrades (City of Frisco, 2014). The criteria used for prioritization by each city and town are shown in Table 5.

*Table 5. Prioritization Criteria for Curb Ramps Reported By Cities and Towns.*

| City/Town | Requests | Condition/ Compliance | Demand/ Pedestrian Generators | Transit | Connectivity |
|---|---|---|---|---|---|
| Loveland, Colorado | Y | N | Y | Y | N |
| Mesa, Arizona | Y | Y | Y | Y | N |
| Frisco, Texas | Y | Y | Y | Y | N |
| Bellevue, Washington | Y | Y | Y | Y | N |
| Euless, Texas | Y | N | Y | N | N |
| Redmond, Oregon | Y | Y | Y | Y | Y |
| Shoreline, Washington | N | Y | Y | Y | N |
| Clayton, Missouri | Y | Y | Y | Y | N |
| Baltimore, Maryland | Y | Y | Y | Y | N |
| Portland, Oregon | Y | Y | Y | Y | Y |
| San Jose, California | Y | Y | Y | Y | N |

| City/Town | Requests | Condition/ Compliance | Demand/ Pedestrian Generators | Transit | Connectivity |
|---|---|---|---|---|---|
| Concord, Massachusetts | N | Y | Y | N | N |

Y = City/town reported using the criterion; N = City/town did not report using the criterion

The information obtained from other states regarding their curb ramp prioritization processes suggests that although there is no standard practice, several states do employ multiple criteria when prioritizing curb ramp upgrades outside of planned paving projects. Citizen requests were the most frequently used criterion, followed by the ramp's physical condition, including ADA compliance. Other considerations such as proximity to pedestrian trip generators, transit, and network connectivity were each employed in at least two states.

Curb ramp prioritization processes at the local level also employed multiple criteria, but in contrast to states, pedestrian demand or proximity to pedestrian generators was the most frequently cited among localities. Citizen requests, ramp condition/compliance, and transit were each cited by all but two localities, while only two localities took connectivity into account when prioritizing curb ramp improvements. One possible explanation for localities' relatively higher use of certain categories may be data availability; for example, a locality may be more likely than a state DOT to have information about transit stops in its jurisdiction.

Given the critical role of curb ramps in a sidewalk network that is accessible for people with disabilities, expanding the consideration of connectivity in curb ramp prioritization may be beneficial. However, data availability may pose a challenge for doing so if most states and localities lack complete information about sidewalks, curb ramps, and crosswalks in a form that can be used for pedestrian network connectivity analyses.

## Conclusion

- This study's findings provide a foundational resource for state DOTs, local and regional agencies, and transit agencies that are developing or revising prioritization processes for curb ramp retrofits as part of an ADA transition plan.
- ADAAG and PROWAG provide similar guidelines/standards for accessibility. PROWAG, adopted by many state and local governments, is more stringent on several criteria, such as widths of ramps and landings. One likely trade-off in using the more stringent, newer PROWAG standards is that relatively more curb ramps will not meet all criteria and will thus require retrofits, bolstering the need for a process to prioritize them.
- All states surveyed had a unique prioritization process in place as part of their ADA transition plans. Physical condition or compliance with standards was most commonly used in prioritization processes; 67% of all responding states considered citizen requests a high priority.

Local governments incorporated transit and pedestrian generators in curb ramp prioritization processes much more frequently than statewide governments. Data availability and diverse geography may pose a challenge for including such factors at a state or regional level where pedestrian infrastructure data is often incomplete.

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# ACCESSIBILITY AND SOCIAL PARTICIPATION IN URBAN SETTINGS FOR PEOPLE WITH AUTISM SPECTRUM DISORDER (ASD) OR AN INTELLECTUAL DISABILITY (ID)

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***Abstract*:** Individuals with Autism Spectrum Disorder (ASD) or an Intellectual Disability (ID) often have difficulties in interpersonal relationships, adaptation to new situations/environments and problem-solving. Today, many of these individuals face the challenges associated with adulthood in an urban setting. Despite the extensive research developed on children with ASD and ID in the indoor environment, little research has been done on the social participation of adults with ASD and ID within urban settings thus far.

This systematic review aims to shed some light on the activities developed by adults with ASD and ID in an urban context, the main facilitators and obstacles of these activities, as well as the means of transportation used to achieve them.

Like the rest of the population, adults with an ASD or ID engage in various activities related to work, leisure, community life or education, using different modes of transportation, including buses, to perform them. The most important obstacles identified are related to interpersonal relationships along with social and physical environments that are not adapted to their needs. In order to address these obstacles, health professionals, including occupational therapists, have a role to play in the development of methods and tools to increase the abilities of people with an ASD or ID. They can also participate in raising awareness among the population and can advocate for changes in the physical environment in urban settings.

***Keywords:*** Systematic review, Adult with ASDs or IDs, Social participation, Urban environment, Urban activities, Modes of transport.

## Introduction

Autism Spectrum Disorder (ASD) is a lifelong condition characterised by significant and persistent difficulties in communication and social interaction, but also by restricted, stereotyped, and repetitive patterns of behaviours, activities, and interests (American Psychiatric Association, 2013). This condition frequently manifests itself as sensory hypersensitivity, making them more intolerant to stimuli such as odours and light.

Intellectual disability (ID), on the other hand, is also a permanent condition, but is defined by deficits in intellectual functions such as reasoning, planning and problem-solving. People with ID generally have difficulty adapting to new situations, which translates into difficulties in their autonomy, but also in managing their emotions and behaviour, in their interpersonal relationships, and in risk assessment (American Psychiatric Association, 2013).

In Quebec, the prevalence of ASDs has risen significantly in recent years. Indeed, it was near 1/1000 in 2000-2001 and increased to 4.6/1000 in 2014-2015 (Institut national de santé publique du Québec). Moreover, according to Shattuck, Wagner, Narendorf, Sterzing and Hensley (2011), a growing number of people with ASDs are moving into adulthood and must face the challenges of their new roles without adequate support from society, which generally leads to social isolation (McCollum, LaVesser and Berg, 2016). However, to our knowledge, research on this population is concentrated more into childhood than adults, with very little documentation on adult occupations and their difficulties. Indeed, the impact of this type of environment, which includes the various components of the urban setting such as the road system, public transit, buildings, ubiquitous advertising, lighting and temperature, parks and vegetation, as well as the people living in the environment, is little assessed among this type of population.

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Although the prevalence of intellectual disability remains stable at around 10.37/1000 (Maulik, Mascarenhas, Mathers, Dua and Saxena, 2011), population growth, better socio-economic conditions and improved health care leading to increased longevity of this population mean that there is an increase in the number of adults with ID in the population (Cooper, Melville and Morrison, 2004). Like individuals with ASDs, people with ID often have decreased social participation (Verdonschot, De White, Reichrath, Bunthix, & Curfs, 2009).

We know that the physical environment is responsible for providing positive and negative stimuli, which can have harmful impacts on the daily lives of some individuals. For example, for almost everyone, noise is a pervasive environmental stressor (Smith and Saintfort, 1989) and according to Smith and Saintfort (1989), it is recognised as one of the most important stressors at work. However, some individuals are more sensitive to external stimuli, particularly those with an Autism Spectrum Disorder (Smith & Saintfort, 1989; Ben-Sasson, Hen, Fluss, Cernak, Engel-Yeger, & Gal, 2009) or an intellectual disability (Lundqvist, 2013). Indeed, according to a meta-analysis by Ben-Sasson et al. in 2009, sensory hypersensitivity can interfere with the performance of their daily activities. Such a situation may lead them to avoid certain neighbourhoods, public places, services and businesses available to the general population and thus limit their social participation (Mayer, DiPaolo and Salovey, 1990).

However, some interventions are slowly emerging to help people with ASDs and IDs deal with these challenges. For example, the “structured social planning” type of intervention consists of creating a schedule of social activities with the client that are related to his or her interests in order to encourage participation, but also to train organisational and social skills and to provide peer support (Ashbaugh, 2017). Another type of intervention is video modelling, which involves training individuals to perform an occupation appropriately by having them watch videos created by peers (Hong et al., 2017). This can be used to help individuals with ASDs or IDs learn how to perform a task, particularly for work.

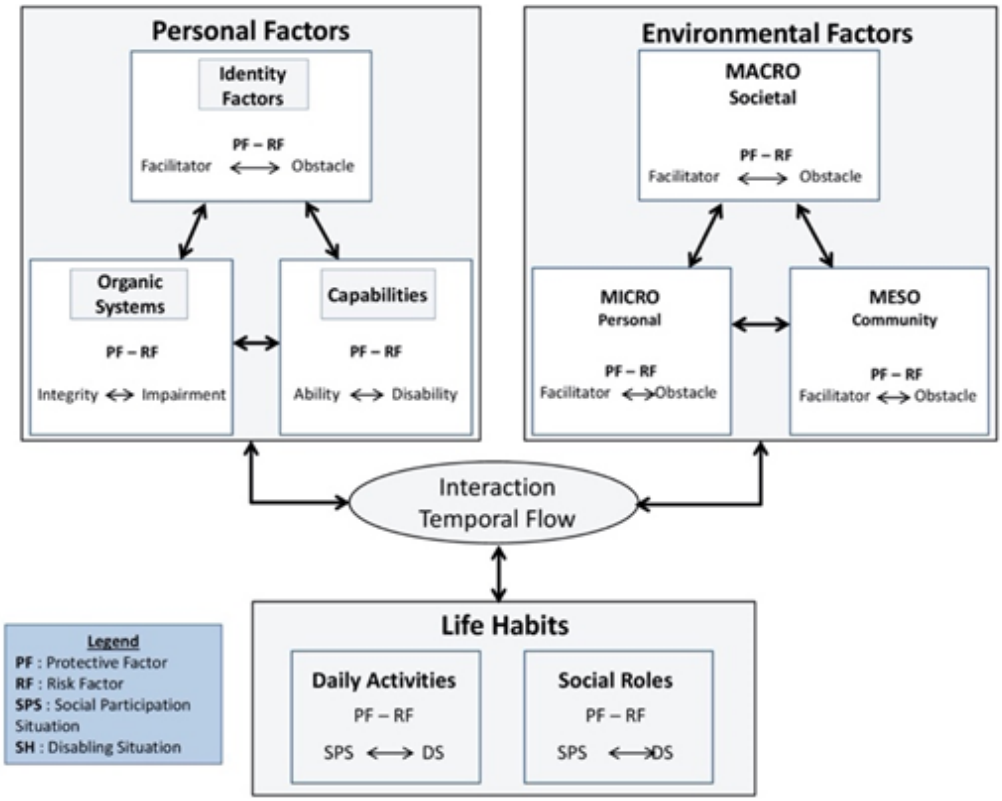
Therefore, given the increase in the number of adults with ASDs and IDs and the lack of research on them in urban settings, it seems important to further

develop the literature on the topic in order to allow these individuals to fully participate in their activities in this environment. This leads us to ask questions such as What are the activities of daily living and leisure that promote social participation among functional adults with ASD and ID in an urban context? And, what means of transportation are most used by functional adults with ASDs or IDs to perform these activities?

## Theoretical framework

In order to analyse the articles, the Human Development Model – Disability Creation Process (HDM-DCP) was used (Figure 1). This model documents and explains how different environmental, personal, and lifestyle factors influence a person's daily life (International Network on the Disability Creation Process, 2020).

*Figure 1. Human Development Model – Disability Creation Process (HDM-DCP).*




This conceptual model makes it possible to highlight both the protective factors, which therefore help to carry out roles and activities, and the risk factors, which contribute to creating a situation of disability. In this model,

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social participation is seen as the result of adequate interaction between personal and environmental factors during a life habit, whereas a situation of disability occurs when these factors are not congruent. Indeed, when there is an interaction between two or more factors that does not work, or works with difficulty, the individual is faced with a problematic situation, an obstacle that may even be impossible to overcome. This model is used in this study to help classify the various information collected in the articles selected in the review.

## Methodology

This study follows the guidelines of a systematic review that consists of a comprehensive and rigorous search where the authors agreed on the choice of databases used, the development of inclusion and exclusion criteria, the free vocabulary and thesauri used in the databases, as well as the selection of articles and the analysis of their quality. However, the underlying purpose of this study is more like a scoping review which is an exploration of the main concepts of a field of research and also allows for verification of the type of results available. It summarises the results about a particular field of research and validates the needs of a research project. It does not usually contain a quality study or practice recommendation, however the authors considered pertinent to develop an assessment of the quality of the articles along with general guidelines.

### Databases, free vocabularies, thesaurus and search operator

Two databases were selected and six concepts were used (see Table 1) to answer the research question and were accessed on November 30, 2019. The first, PsycNET, is an important source of journal articles in psychology and psychiatry with content useful to many areas of the health sciences. The second is Web of Science, which offers sciences, social sciences, arts and humanities articles and covers multiple databases. It is important to note that there is no thesaurus in this database.

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*Table 1. Concepts used when searching databases.*

| Concept | Name |
|---|---|
| 1 | Population |
| 2 | Urban environment |
| 3 | Urban activities |
| 4 | Means of transportation |
| 5 | Home activities |
| 6 | Adult |

Thus, for the main question, the concepts “population”, "urban environment", "urban activities" and "adults" were used with the Boolean operator "AND" while the concept of "home activities" was added with the operator "NOT" to narrow the scope of the search. In effect, this eliminates articles dealing with social participation at home, which is not covered in the spectrum of this article.

Then, for the sub-question, the concepts "population", "means of transportation" and "adult", with the operator "AND", made it possible to search for articles related to the means of transportation used by adults with ASD/ID when travelling in an urban environment.

Subsequently, the keywords used for the six concepts in the two databases and the thesaurus used in PsycNET are grouped in Table 5 in the appendices.

## Inclusion and exclusion criteria

The inclusion criteria reflect the study population, which must have an ASD and/or a functional ID: these adults must be able to perform their Activities of Daily Living (ADLs) and travel to urban areas independently or with minimal assistance. Articles must address social participation and be in English or French.

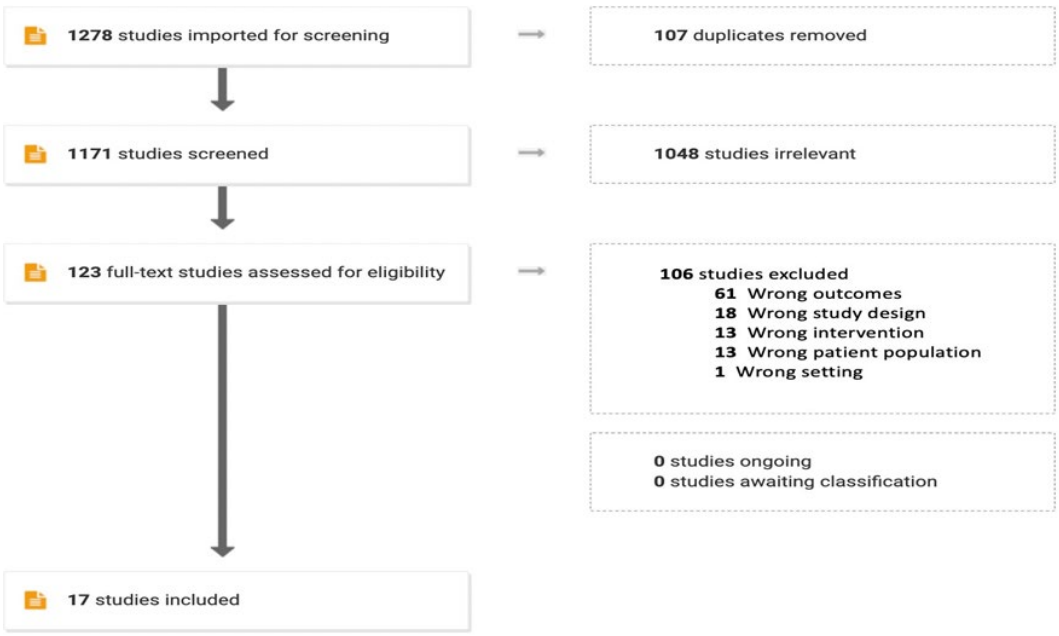
Articles providing information only about people with ASDs or non-functional IDs who are not able to perform ADLs and go to an urban setting independently or with mild assistance were not included. In contrast, articles that also contained information on a more functional population were not rejected. Articles that addressed individuals with multiple diagnoses were also rejected

in order to avoid including factors that are not related to our study population. In order to address social participation exclusively in an urban context, articles addressing social participation in the home were rejected. Finally, duplicates, abstracts of oral presentations or conferences, research protocols, theses and research papers were rejected.

## Selection process

As a result of the selection process, 1278 articles were identified in the research databases. Since 107 of them are duplicates, the selection process by abstract was carried out on 1171 articles to highlight 123 articles that corresponded to the inclusion and exclusion criteria. Of these articles, 17 were retained after the full reading selection process. This is summarised in Figure 2.

*Figure 2. The Prisma. Created using Covidence software (www-covidence.org) on August 16, 2020.*




## Quality Assessment of the Articles

In order to evaluate the quality of the articles identified, the critical review grid for quantitative articles (Law et al., 1998) and the equivalent version for qualitative articles (critical review grid for qualitative articles) (Letts et al.,

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2007) were used. These two grids provide similar ratings allowing a similar analysis of the articles.

The grid for quantitative articles contains 17 criteria addressing the purpose of the study, the literature review, the study design, the sampling, the results (metrological qualities), the intervention, the data analysis, the clinical significance and the conclusion. The grid for qualitative articles contains 20 criteria addressing study purpose, literature review, study design, sampling, data collection, procedural rigour, data analysis (scientific rigour, verifiability, theoretical linkages), metrological quality and conclusion.

The quality of the papers was evaluated by the two authors separately, and then a consensus was reached by argumentation on the divergent points. The authors first evaluated four articles in order to ensure a unanimous understanding of all the items of the grids.

## Level of scientific evidence

In order to assess the level of scientific evidence, the 2001 version of the Oxford Centre for Evidence-Based Medicine (CEBM) grid was used (Centre for evidence-based medicine, 2016). The latter allowed for hierarchical classification of articles to highlight those with a higher level of scientific evidence and stronger proof. As in the quality assessment, the level of evidence was analysed by two reviewers and a consensus was reached.

## Data extraction method

Data were also extracted by two individuals separately before being pooled in a consensus. The papers were distributed in three different tables according to their population. The first table groups the articles dealing with individuals with an ASD, the second with individuals with ID, while the third contains the articles that include both individuals with an ASD and ID. These extraction tables are based on the components of the HDM-DCP and make it possible to highlight the objective of the study, the lifestyle, environmental and personal factors presented in the articles identified, as well as to group together the quality of the various studies in order to compare them. The following table is an example:

*Table 2. Sample Data Extraction Table.*

| Authors (date) | Title | Purpose of the study and estimate | Methodology | Personal and environmental factors | Life habits | Results | Quality assessment according to Letts and CEBM |
|---|---|---|---|---|---|---|---|

## Results

### Quality Index and CEBM

From this literature review containing 17 articles, a mean overall quality of 68.62% and a median of 66.7% emerged. It should be noted that the quantitative articles had an average and median quality that were about 10% (11.96% and 9.7%, respectively) higher than their qualitative counterparts (Table 6). The two lowest articles are those of Deka, Feeley and Lubin (2016) and Lubin and Feeley (2016) with a score of 50%, while the highest is the article of E. Curry, E. Yerys, Huang and Metzger (2017) with a score of 87.5% followed by Zalewska, Migliore and Butterworth (2016) with a score of 83.3%.

*Table 3. Means and medians quality of articles.*

| Studies Quality | Means (%) | Median (%) |
|---|---|---|
| **Quantitative Studies** | 73,27 | 72,2 |
| **Qualitative Studies** | 61,31 | 62,5 |
| **Overall** | 68,62 | 66,7 |

For the CEBM quotation, out of 17 articles, the majority have a score of 3b (non-consecutive cohort study, or very limited population). The other articles are divided, in order of importance, into the following four ratings: rating 5 (expert opinion without an explicit critical appraisal, or based on physiology, bench research or "first principles"), rating 2c (ecological studies), rating 2b (retrospective cohort study, or poor follow-up) and rating 3a (systematic

review of 3b and better studies) (Table 4). Thus, the strength of the body of evidence according to the CEBM rating is 3b.

*Table 4. Number of Articles by CEBM score.*

| CEBM score | Number of articles | CEBM score | Number of articles |
|---|---|---|---|
| **1a** | 0 | **2c** | 2 |
| **1b** | 0 | **3a** | 1 |
| **1c** | 0 | **3b** | 10 |
| **2a** | 0 | **4** | 0 |
| **2b** | 1 | **5** | 3 |

## Lifestyles Habits

The diverse lifestyles of people with ASDs and IDs found in the articles fall into five of the HDM-DCP categories: interpersonal relationships, transportation, work, leisure or community life, and education. Therefore, the risk and protective factors have been separated into these categories to better integrate them into their context.

### *Interpersonal relationships*

Some individuals with ASD take public transport to go shopping, work, school or social activities with family and friends (Deka, Feeley & Lubin, 2016). Although feeling understood and accepted is an important factor in employment and good social interaction (Nouf-Latif, Andersson and Markström, 2019), being called "disabled" at work may have a very negative effect on them. For people with ID, leisure and employment are often the main occupations that allow them to have relationships outside the family framework. At work, some develop good relationships because of the time spent on breaks and outside of work, but some have few opportunities to interact with their colleagues since they only work a few hours and therefore do not have a break. In addition, youth with ID feel accepted when they are treated like everyone else in their jobs and people talk to them. (Hall, 2016). Even though some are more introverted and seek less companionship from others, some are able to create a network of friends that allows sharing and emotional support (Randell & Cumella, 2009).

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### *Transportation*

In terms of means of transportation, eight articles have addressed this issue among people with ASD, being a challenge for 26% of them (Zalewska, Migliore, & Butterworth, 2016). The most used mode of transportation is “to be a passenger in a family car”, “a friend's or a volunteer's car”, followed by “walking” and then “public transport”, with “driving a car” being the last (Deka et al., 2016). Some report that having a license and a car would increase their freedom to make spontaneous trips (Lubin and Feeley,2016). In addition, although ASDs have more difficulty in areas with traffic, right turns, and yielding due to the need to interact with other drivers, they can compensate for this difficulty through their marked adherence to rules such as the appropriate use of the turn signal (Chee, Lee, Patomella, & Falkmer, 2017). Proper use of this signal can reduce confusion for other drivers and avoid accidents. Stress levels vary among this population concerning car use, and many prefer to use other modes of transportation (Chee et al., 2015). Compared with these modes, people with ASDs would generally be comfortable using public transport, but some prefer to drive or are uncomfortable in crowded conditions (Falkmer et al., 2015). In terms of walking, most people with ASD are as confident as neurotypical individuals (Earl, Falkmer, Girdler, Morris, & Falkmer, 2018) in using pedestrian crossings or shared areas.

Concerning transportation for people with ID, it implies a real challenge for 31% of them (Zalewska et al., 2016). The main forms of transportation used would be “being a passenger in a relative's or friend's car”, “paratransit”, or “public transit” (Hall, 2016). However, this varies with age. For seniors with ASD or ID, “paratransit” becomes the preferred mode of transportation, followed by “being a passenger in a family member's car or a cab” (McCausland, Stancliffe, McCallion and McCarron, 2019). They would also be less confident than neurotypicals in using pedestrian crosswalks or shared areas.

### *Work*

Three articles sustain that individuals with ASD are often determined to accomplish the goals they have set for themselves, and that personal ambition

is a motivating factor, as for many neurotypical individuals. In addition, 74.5% of people with ASDs would travel to work, while 86.6% would travel to school or a vocational training program (Deka et al., 2016) and independent transportation would significantly increase access to employment (Zalewska et al., 2016). Concerning "work" and individuals with ID, seven articles addressed the high attachment invested to their jobs, as well as the feelings of being lazy and useless when losing a job (Banks, Jahoda, Dagnan, Kemp, & Williams, 2009). In addition, following an employment assistance program, 30% of the first job was in maintenance while 24% was in sales, and 77% of participants changed jobs at least once in two years. (Botuck and Levy, 1998). Most jobs are part-time and are quite varied (such as grocery, store, or respite care), and it may be more difficult for some to find or keep a job (Hall, 2016). Some also volunteer in addition to their jobs. (Hall, 2016). Finally, one article discussed employment for people with ID in an "Intentional Community". These groups of people who have decided to live together according to certain rules vary from each other depending on the intent behind their creation, but they are generally based on mutual support, sharing and community life. Thus, in the community studied, people with ID find that their employment is important in their daily lives and that it is pleasant to be able to change jobs easily (Randell, 2009). Indeed, some mentioned that it was easier to find a new job in that environment if the last one did not suit them, which reduced the stress, boredom, and feeling of uselessness caused by a transition that is too long and marked by employer rejections. (Randell and Cumella, 2009; Banks et al., 2009).

### *Leisure and community life*

People with ASDs are more likely to use transportation to engage in leisure or community activities such as shopping, recreational or social activities, religious services, or family and friends visits (Deka et al., 2016). Concerning individuals with ID, many are involved in structured activities such as sports leagues, unstructured activities such as bowling, and social activities such as dance and art, community events or liturgical activities (Hall, 2016). For some, going shopping is a sign of autonomy of decisions, choices and responsibilities, while providing a certain amount of pleasure and allowing social skills to be practised outside the family group (Wilton, Fudge Schormans and Marquis,

2018). Finally, for people with ID who were part of an "Intentional Community", there were many leisure activities, both at home (such as music or drawing) and outside the home (such as going to coffee, choir, or theater). They mentioned that the feeling of security is very important for them in carrying out these activities. (Randell and Cumella, 2009).

## Discussion

In this section, the results of the literature review will be highlighted in order to provide an overview of the lifestyle habits of individuals with ASDs and IDs. Thus, the different lifestyle habits will be explored in order to highlight the main facilitators and barriers that limit the social participation of people with ASDs and IDs. After presenting the difficulties and facilitators encountered for them during their occupations in the urban environment, possible solutions will then be discussed.

The above literature review shows that people with IDs and ASDs experience many types of relationships in their daily lives, ranging from couples, families and friends to work relationships, and this can influence their feelings about their choice of activities, as is the case for the general population (Deka et al., 2016; Hall, 2016; Nouf-Latif et al., 2019,). The fact that these individuals have more difficulty than neurotypicals in understanding the feelings of others, expressing their own feelings and interpreting non-verbal cues (American Psychiatric Association, 2015) can lead to inappropriate social behaviours or misunderstanding by others, and this is one of the greatest barriers they face in carrying out and performing their activities in an urban setting (Deka et al., 2016; Hall, 2016; Nouf-Latif et al., 2019).

The unpredictability of social relationships can also be a source of anxiety for people with ASDs and IDs (American Psychiatric Association, 2015; Autisme Québec, 2020) while making it more difficult for them to perform these activities, diminishing their desire to participate. In addition, difficulties in interpersonal relations have a collateral effect that can affect the completion of urban occupations. Indeed, adolescents and young adults with ASDs or IDs often have less opportunity to learn with or from their peers, some essential knowledge of the proper use of the various systems present in a city. For

example, it is common for young people to explore the city with friends using public transit. This allows them to learn how to locate themselves in the environment, use public transit efficiently and find their way back if they need to. The fact that people with ASDs or IDs have less access to this type of experience may affect their ability to move around the city later on. Another example would be going to restaurants or shopping without parents. Indeed, without them, a young person is forced to interact with the adults who work in these places, which allows him or her to develop autonomy. Thus, doing activities with peers in an urban setting is a frequent means of learning that allows young people to develop their autonomy and face architectural barriers. Unfortunately, this means it is less used among people with ASD or IDs due to their difficulties developing relationships with their peers. Therefore, the impact of the interpersonal barrier is a major obstacle for these populations in their relationships and in their activities in an urban setting, such as their job.

This review of the literature shows that several barriers could influence their ability to have a job, being most striking the need to interact with others. As this can make tasks more difficult because of misunderstandings, inappropriate social behaviour and anxiety caused by social interaction (Deka et al., 2016; Hall, 2016). For example, work that requires numerous group meetings can become anxiety-provoking for people with ASDs and increases the risk of misunderstandings that can lead to frustration among colleagues. Another important challenge was not being able to travel to work independently due to transportation that was not adapted for them, such as a complex bus route requiring multiple transfers (Deka et al., 2016; Lubin et al., 2016;), and a smaller percentage of them having a driver's license (Curry et al., 2017; Deka et al., 2016; Zalewska et al., 2016). Furthermore, Smith et al. (1989) suggest that environmental stimuli such as noise or light can interfere with work performance and well-being. This is all the more pronounced in people with ASDs (Smith et al., 1989; Ben-Sasson et al., 2009) or people with IDs (Lundqvist, 2013) due to their sensory hypersensitivity.

Concerning the facilitators that were found, having a position that is rewarding and feeling accepted in the community greatly helps the integration of people with ASDs or IDs (Nouf-Latif et al., 2019). Also, having access to pre-

service training (Nouf-Latif et al., 2019), a workplace trainer (Hall, 2016), or job-specific education (Nouf-Latif et al., 2019) is also an important aid to obtaining and maintaining employment. Moreover, it is preferable to highlight strengths rather than difficulties when meeting with employers in order to improve their attitude towards people with ASDs or IDs (Nota, Santilli, Ginevra, & Soresi, 2014) and to find a job that is adapted to the person and their strengths, which facilitates integration, productivity, and satisfaction (Hall, 2016). For example, a job that requires little social contact and corresponds to the person's strong interests will make it easier for the person to carry out his or her tasks while increasing the chances of keeping the job in the longer term. Finally, being able to travel independently is also a major asset (Zalewska et al., 2016).

Education is also an important occupation for the well-being of people with ASDs and IDs, and many hope to go on to post-secondary education (Cheri Wallace, 2016). As mentioned previously, difficulties in communication and social interaction, associated perceptual and physical difficulties, and learning disabilities that may be present, can make learning more challenging. According to Cheri Wallace (2016), school is also a way for them to develop their social skills, experiment with new situations and even feel pride in their academic, social or daily life management success. As with students in general, the presence of supportive relationships, whether with family, friends, or teachers, enables individuals with ASDs to remain in the school environment for longer periods of time (Cheri Wallace, 2016).

In relation to leisure activities and individuals with ASD and ID, some barriers are the environmental stimuli (Smith et al., 1989), the social relationships needed to perform the activity (Hall, 2016; Deka et al., 2016; Nouf-Latif et al., 2019), accessible modes of transportation and the ability to use them (Chee et al., 2015, Chee et al., 2017; Deka et al., 2016; Falkmer et al., 2015), along with the choice and cost of available activities. Indeed, according to Bodde et al. (2009), lack of financial resources, support from others, and transportation options were the most recurring factors preventing people with IDs from engaging in physical activity. One example to illustrate this could be having a gym membership which can be quite expensive and require a complex organisation that can be difficult for a person with IDs (such as planning the

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different steps - necessary travel, change of clothes, toiletries, etc.-. the use of machines or the relationship with other users). In addition, some people with IDs may have some difficulty managing risk because of impaired judgment and learning difficulties (American Psychiatric Association, 2013). Therefore, their family and friends are often reluctant to allow them to practise this type of activity because of the risk of injury related to the use of machines or sometimes complex training methods. As it happens with everyone else, the support of family members, peers and caregivers often facilitates leisure activities and the rewards that come with some of them (e.g. volunteering) (Hall, 2016; Wilton et al., 2018). The independence these activities provide is also a factor that encourages individuals with ASDs and IDs to persevere and practise their communication skills in this context (Hall, 2016; Wilton et al., 2018).

The second research question addressed the means of transportation and destination that people with ASDs and IDs make in their daily lives. For example, the articles indicated that they typically travelled to work, school, or various leisure or community activities (Deka et al., 2016; Lubin et al., 2016; Zalewska et al., 2016). According to Sherman and Sherman (2013), the lack of accessible and adapted modes of transportation such as buses or subways is one of the barriers that most limit inclusion and social participation in the community. Indeed, despite the presence of public transit, the difficulties associated with IDs or ASD make the system difficult to use for these populations (Deka et al., 2016; Falkmer et al., 2015; Hall, 2016; Lubin et al., 2016; McCausland et al., 2019). For example, long, complex, frequent trips requiring numerous stops and transfers are common. This can be problematic for everyone, but a person with ASDs or IDs faces additional challenges in having relationship difficulties, as they will not tend to seek help when needed and may not know whom to ask for help or how to ask for it (American Psychiatric Association, 2015; Autism Quebec, 2020; Deka et al., 2016; Lubin et al., 2016). In addition, the lack of education regarding the use of public transportation for people with ASDs and IDs also increases the fear of using public transportation (Lubin et al., 2016) and limits their ability to use public transportation due to a lack of practice and knowledge about procedures, how to follow and the meaning of different signs.

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Having access to education can make urban travel easier, both in terms of walking and using public transit (Lubin et al., 2016). Access to a driver's licence is also a major asset for people with IDs or ASDs, since it allows them to be more independent in their movements and thus to more easily carry out their desired occupations (Zalewska et al., 2016). For people with ASDs, walking is also a relatively easy mode of transportation despite sensory stimulation, which is sometimes increased. People with ASDs generally feel more confident walking than taking public transit or driving a car (McCaulland et al., 2019). However, this is not always the case for individuals with IDs, since they have more difficulty crossing the street (McCaulland et al., 2019) than neurotypical individuals or individuals with ASDs.

## Possible solutions

As a result of this research, several solutions seem to be interesting avenues to facilitate the realisation of occupations in an urban context for people with ASDs or IDs to strengthen interpersonal relationships and promote social participation.

First, in the category of leisure and community life, health professionals could advocate for changes to increase opportunities for people with ASDs and IDs and to facilitate the realisation of those already present in the community. For example, they could plead for greater accessibility to sports activities by encouraging adapted and inclusive sports groups. Architects and designers could contribute with more inclusive recreational environments, such as the use of soundproofing materials that would reduce the risk of noise-related sensory overload or arenas and gyms with adjustable brightness to reduce light-related surcharge. The development of training workshops on social interactions could also help reduce the fear and difficulties encountered during occupations in an urban environment. More specifically, in the school context, a structured social planning intervention (Ashbaugh, 2017) can be used, in collaboration with occupational therapists and specialised educators, to increase the social skills of individuals with ASDs, thereby increasing their quality of life and well-being, as well as their academic performance and the variety of social activities in which they participate (Ashbaugh, 2017; Koegel, Ashbaugh, Koegel & Detar, 2013).

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Second, mobilising health professionals and human resources experts to improve work prospects by raising awareness among employers about the skills and contributions that an individual with an ASD or IDs can bring to their business could facilitate job search for these populations. Similarly, raising awareness of the difficulties of social interaction with co-workers would also help facilitate the integration of individuals of these populations. In addition, occupational therapists and social workers could have a role in creating and delivering workshops to support the development of work skills to enhance the abilities of individuals with ASDs and IDs to find and keep jobs more easily, given their knowledge of the strengths and limitations of this population. Indeed, people with ASDs frequently have good levels of concentration, good visual acuity, and a predisposition to be more effective because they prefer to be alone (Sénéchal, Fontaine, Larivée, & Legault, 2019): compared to other workers, they waste less time talking to each other, which increases their productivity (Hurlbutt & Chalmers, 2004). These strengths, coupled with a strong interest in certain fields, which increase their knowledge and motivation on these subjects, make them good candidates for certain jobs or fields, for example, in the video game or software industry. Thus, health professionals could also educate the employers about the benefits of hiring people with ASDs and IDs as part of their work team. This could indeed help to reduce the higher unemployment rate among these populations, as noted in Shattuck et al. (2012)

Third, in relation to travel and transportation, it would be necessary for health professionals to act in collaboration with urban planners and transportation experts at the macroscopic level by advocating for changes in the transport system, including simplifying the complexity of trips and the information regarding the schedules and signalisation for the transfers. This can also be achieved by increasing and organising the number of visual cues providing information at stations or on buses to make it easier for users to understand. As in the workplace, raising awareness among employees and transit users about the social interaction difficulties of some people, such as those with ASDs and IDs, could reduce problematic contacts, thereby increasing the sense of safety and confidence in using this type of transportation. Training also appears as an effective way to make people with ASDs and IDs safer about

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using public transit (Deka et al., 2016; Lubin et al., 2016). Therefore, the creation of an educational program on this subject could have positive effect on the urban social participation of these populations. This could provide an opportunity for youth with ASDs and IDs to learn the basics and practice using different types of public transportation with their peers. This type of learning could potentially increase the ability of these youths to be self-sufficient in an urban setting, while practising their ability to interact with others. Similarly, training for driving school staff on the common difficulties faced by people with ASDs and IDs, such as yielding off, and how to teach them how to drive safely and independently, could improve their ability to drive safely and independently.

### Limits

The quality index of the articles is variable (between 50% and 87.5%), which may diminish the validity of the results of this study, as are the CEBM score, which were mostly in categories 3a, 3b and 5. Moreover, some studies did not divide their study populations according to disability for all results, which may also cloud some of our conclusions. Indeed, since the present study includes people with high-functioning ASDs and people with mild IDs, having articles in which some participants have more severe disabilities may alter the overall picture of client difficulties.

## Conclusion

Despite the limitations of this literature review, it appears from the literature that the main difficulties for people with ASDs or IDs to carry out their occupations in the urban environment come from their relational difficulties and an unsuitable social and physical environment. Thus, to facilitate the performance of their occupations, it is necessary to find ways to improve their social skills in these activities, for example, through training, while improving the environment in which they live, by means such as awareness-raising and changes in visual cues. Health professionals, social workers and architects have an important role in adapting the environment, creating tools or methods that facilitate the activities of these populations, and advocating the

appropriate authorities to increase the occupational opportunities for people with ASDs and IDs.

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## Appendices

*Table 5. Free Vocabularies and Thesaurus Used.*

| Concepts | Free vocabulary | Thesaurus (PsycNET) |
|---|---|---|
| Population | ASD OR autis* OR asperger* OR "Autism spectrum disorder" OR "Autistic disorder" OR "Aspergers syndrome" OR "intellectual disabilit*" OR "Intellectual Development Disorder" OR "Mental retardation" | {Autism Spectrum Disorders} OR {Intellectual Development Disorder} |
| Urban environment | Urban areas " Or "Urban environment*" OR city OR Urban OR Town | {Urban Environments} |
| Urban activities | Activit* OR Work OR "Human activit*" OR Hobb* OR education OR Leisure OR "Leisure time" OR "recreation area*" OR Museum* OR Bank* OR Restaurant* OR cinema OR Park* OR "Shopping center" OR mall OR grocery OR Drugstore | {Active living} OR {hobbies} OR {Leisure time} OR {Recreation} OR {Museums} OR {Banking} OR {Recreation Areas} OR {Shopping Centers} |
| Means of transportation | Pedestrian* OR Bus OR buses OR car OR “public transport” OR travel OR Transportation | {Public Transportation} OR {Automobiles} OR {Pedestrians} |
| Home activities | Home OR “Activity of daily living“ OR “Daily living activit*“ OR house OR hygiene OR dressing | {Activities of Daily Living} OR {Household Management} OR {Hygiene} |
| Adult | Adult OR “young adult” | {Adult Offspring} |

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