

DEVELOPMENT OF A MEASURE OF ACCESSIBILITY TO URBAN INFRASTRUCTURES: A CONTENT VALIDITY STUDY

Original clinical research

Authors:

Stephanie Gamache^{1,3}
Claude Vincent^{1,2}
François Routhier^{1,2}
Bradford James McFadyen^{1,2}
Line Beauregard¹
David Fiset¹

AUTHOR NOTE :

¹Centre for Interdisciplinary Research in Rehabilitation and Social Integration, Centre intégré universitaire de santé et de services sociaux (CIUSSS) de la Capitale-Nationale – Institut de réadaptation en déficience physique de Québec, Québec, Canada

²Rehabilitation Department, Faculty of Medicine, Université Laval, Québec, Canada

³ Social integration program, Centre intégré universitaire de santé et de services sociaux (CIUSSS) de la Capitale-Nationale – Institut de réadaptation en déficience physique de Québec, Québec, Canada

Corresponding author:

Claude Vincent, PhD, OT(c)
Centre for Interdisciplinary Research in Rehabilitation and Social Integration, Centre de santé et de services sociaux de Québec-Nord, Institut de réadaptation en déficience physique de Québec
525 Wilfrid-Hamel Blvd. East
Québec, Québec, Canada, G1M 2S8
E-mail: claud.vincent@rea.ulaval.ca
Phone: (418) 529-9141 6626
Fax: (418) 529-3548

ABSTRACT

Background: Accessing urban infrastructures, such as educational and leisure facilities, is often a challenge for wheelchair users, blind and deaf people, and older adults with and without assistive devices. Rehabilitation professionals are the ones who assess the built environment to make sure that it is accessible for all kind of disabilities; they are providing professional recommendations if it is not accessible. Occupational therapists and other rehabilitation professionals are also asked to provide accessible recommendations before the construction of urban infrastructure as well. There is a need for a comprehensive measure of the built environment of exterior and interior urban infrastructures to evaluate access for individuals with physical disabilities (motor, visual, hearing), using assistive technologies or not, to foster their social participation and fair access rights. This paper describes the development and content validation of the Measure of accessibility to urban infrastructures for adults with physical disabilities (MAUAP).

Method: This process of developing a measurement tool in health involved three steps: 1) consultation of the scientific and grey literature, 2) content development, and 3) content validation with two panels of experts including a field pretest.

Results: The MAUAP includes seven independent sections: parking lot, pedestrian facilities, building access from the exterior, interior maneuvering areas, infrastructures for learning and leisure, services and public restroom. Items are assessed with the percentage of characteristics present (1 to 16) and an accessibility score (4-level ordinal scale).

Conclusion: The MAUAP allows the identification of precise accessibility recommendations that can be useful for health professionals and other professionals involved in conception and refection, such as architects and city planners.

Keywords: *Evaluation of built environment, assessment of accessibility, wheelchair mobility, inclusive design, public buildings; pedestrian facilities; educational and leisure facilities*

1. Introduction

In rehabilitation and community services, clients are often confronted with mobility problems. Even if assistive technologies are helpful for mobility, walker, wheelchair, scooter, guide dog and hearing aid users report difficulty accessing urban infrastructures. One of the rehabilitation professional's goals is to promote accessibility in the community to encourage clients' participation [1-10], with and without assistive devices. This can be achieved by, among other things, an evaluation of the built environment of urban infrastructures in order to inform clients about their accessibility level with regard to their impairments and to provide recommendations to improve their use [1,3,9,11-15]. Ultimately, every individual deserves fair access to the infrastructures he/she wishes to use. An important step in providing accessible infrastructures is to assess them from the perspective of inclusion of all disabilities.

To date, there is no objective, valid and reliable measure that considers people's physical disabilities (motor, visual, hearing) when analysing exterior and interior access to the built environment of urban infrastructures [16]. Laws addressing the built environment are meant to foster social participation and equal

access rights for people with disabilities, but their application is not always effective since many environmental barriers persist [7,17]. At present, the goal of covering as many environmental variables as possible to exhaustively evaluate the accessibility level of both exterior and interior urban infrastructures for adults with different physical disabilities could be attained through the use of a combination of measures. However, such a task is very complex and virtually unachievable. Firstly, a combination of measures developed in different countries, with differing accessibility norms and regulations, would be very difficult to interpret. Secondly, the results obtained would be challenging to analyse since the measures' structures and rating scales would not necessarily be consistent. Thirdly, existing measures generally target one or two specific types of disabilities (individuals with mobility impairments who use wheelchairs or other mobility devices, people with visual limitations, etc.), and never cover all populations presenting different physical disabilities who may have conflicting needs [16]. And finally, there is no measure that includes both exterior and interior variables of urban built environments, including educational and leisure establishments [16].

A more comprehensive measure allowing the analysis of the built environment of urban infrastructures would strengthen the ability to assess environments with respect to individual capacity; the results of such an analysis would enable communication between all professionals involved in construction or refection projects if the measure comprises objective and measurable characteristics of the built environment [18,19]. This paper describes the content validation process of the Measure of accessibility to urban infrastructures for adults with physical disabilities (MAUAP).

2. Research method

The development of this measure comprised three steps: 1) consultation of the scientific and grey literature, 2) content development, and 3) content validation of the measure with two panels of experts including a pretest in the field. The research protocol was reviewed and

approved by the ethics committee of the Institut de réadaptation en déficience physique de Québec (Quebec City, Canada; project #2010-218).

2.1 Consultation of the literature (step 1)

Firstly, to identify existing measures of accessibility with a view to developing a comprehensive measure considering individuals with motor, visual and hearing disabilities, the literature was reviewed. The MAUAP was developed in 2010-2012 and it included scientific articles published up to 2010 in CINHALL and PubMed to identify pertinent accessibility measures of the built environment of pedestrian, learning (educational), and leisure infrastructures for adults with physical disabilities (mobility, visual or hearing). The keywords used, with all possible combinations using and/or, are presented in table 1. Inclusion and exclusion criteria and their rationale are detailed in figure 1.

Table 1. Keywords used for the literature review search

Keywords used for which results were obtained			
accessibility checklist	architectural accessibility	assessment	assessment instrument
audit tool	built environment	city planning	disabled persons
elevators and escalators	environment	environmental barriers	environment design
evaluation	facility design and construction	disability	hearing disorders
location directories and signs	mobility limitations	neighbourhood environment	outcome and process assessment (health care)
physical environment	practice guidelines as topic	rehabilitation	school environment
schools	universities	urban alleyways	urban street
visual impairment	wheelchairs		
Keywords used for which no results emerged			
crossing	crosswalk	design standards	environment control
floors and floor coverings	handicap, intersection	parking facilities	public building
public facility	universal design		

Secondly, the grey literature (normative and public documents) was reviewed to identify relevant documents concerned with the same subject, but providing another perspective. This review was carried out on the WEB employing the same keywords used for the scientific literature review as well as on government websites concerned with construction. This was done to potentially qualify and quantify environmental characteristics of urban infrastructures through relevant regulations and building codes. These documents were mainly developed by Canadian organisations; however,

documents from other countries were also consulted.

Figure 1 summarises the methodological steps used for the review of the scientific and grey literature (dark boxes) as well as the results extracted (light boxes). A total of 67 measures (95 papers) evaluating the built environment were identified as relevant for the evaluation of accessibility of urban built environments for individuals with various physical disabilities [16]. In addition, 53 public documents (norms, regulations, best practices) on urban accessibility were found. Seven were

selected for their applicability [20-28]. Table 2 presents the exterior and interior subvariables of the built environment found in the 67 measures extracted from the scientific literature. Table 3 describes the 13 measures identified as relevant for the development of a measure of

accessibility of the built environment of urban infrastructures since, when taken together, they include all variables used to describe exterior and interior built environments.

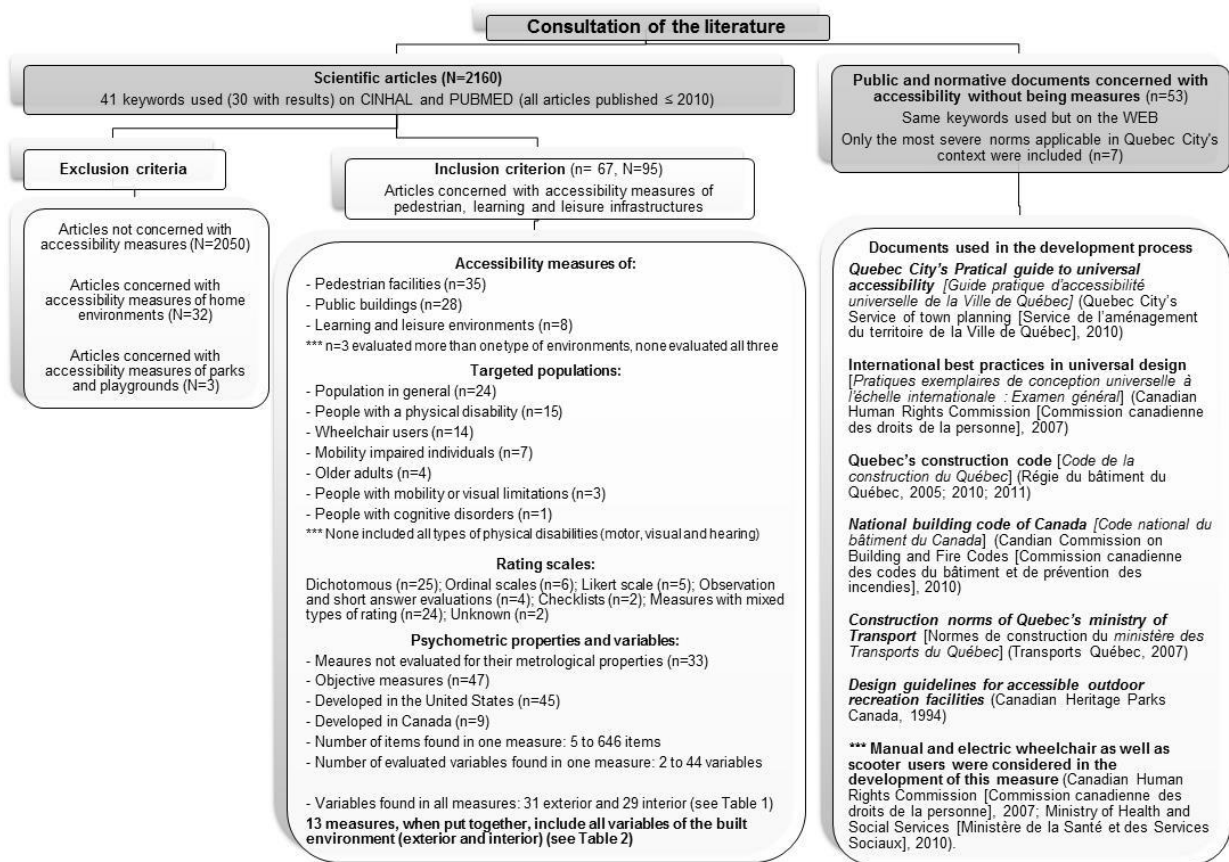


Figure 1. Methods used and results obtained from the consultation of the literature (N = number of documents, n = number of measures)

Table 2. Subvariables of the built environment extracted from 13 measures of accessibility identified in the scientific literature review

Exterior variables	Interior variables
Aesthetics and maintenance*	Cafeteria (shelves, utensils, menus, tray-slide)
Bench*	Controls
Bicycle lane	Desk, counter
Buffer zone	Door
Crossing, crosswalks, intersections and pedestrian lights	Elevator
Curb cut, curb ramp	Fitting room
Drop off area / Access aisle	Floor surface
Ground	Hallway, aisle
Handrails	Handrails
Land use access and diversity*	Hotel room*
Lighting	Information / signage
Main entrance / Entrance area	Lift
Manhole, drainage grate	Lighting
Parking (including surface)	Locker room
Path	Pool*
Path to main entrance	Public washroom / restrooms
Public transportation*	Ramp
Ramp	Safety practices, emergency
Shoulder*	School environment (classrooms, library, reading-study area, computer station, gymnasium, auditorium)
Sidewalk	Seating and table area
Signage	Shelf
Slope	Shower
Sporting area, recreation facility, pool*	Specialized equipment
Stairs, steps, level changes	Stairs, steps, level changes
Street furniture	Telephone
Telephone*	Threshold
Threshold	Time / distance*
Toilet*	Wall finishes
Time / distance*	Water or drinking fountain
Traffic, streets and safety*	
Water or drinking fountain*	

* indicates variables not considered in the development of the MAUAP (exclusion criteria: parks, playgrounds and public transportation)

Table 3. Measures and characteristics found in the scientific literature identified as relevant for the development of a measure of accessibility of the built environment of urban infrastructures

Measure (n = 13)	Specific considerations
Pedestrian facilities	
1. <i>Curb ramp accessibility measure</i> [1]	1. Curb ramps' gutter counter-slope; absence of irregularities, holes or man holes; alignment of the sidewalk with the crosswalk
2. <i>Walking route audit tool for seniors [WRATS]</i> [2]	2. Older adults with visual disabilities; visual demarcation at sidewalk-street transitions
Interior and exterior access	
3. <i>Walkability, Security and Shopping surveys</i> [3]	3. Objectively considers exterior lighting
4. <i>ADA checklist for existing facilities 2.1</i> [4]	4. Signalled accessible entrance or indications for the path leading to one; tables should have places without chairs for wheelchair users
5. <i>ADA checklist for new lodging facilities</i> [5]	5. Pedestrian facilities; signage should be in raised lettering for visually disabled people
6. <i>ADA checklist for polling places</i> [6]	6. Objective evaluation of stairs (not formally included in the measure presented in this paper, but indicators are proposed) including closed off staircases or staircases protected by detectable cues on the floor indicating that the clearance is of less than 2 m
7. <i>Accessibility checklist – a self-assessment tool</i> [7]	7. Door handle configuration (35 to 45 mm door-handle distance)
8. <i>Survey of accessibility</i> [8]	8. Functional accessibility; presence of a path to the main entrance where one does not need to circulate behind vehicles
9. <i>Measuring up : built environment self-assessment guidelines</i> [9]	9. Canadian measure based on the principles of universal design; dispensers operable with a fist without torsion of the wrist; configuration of tables as well as back and arm rests
10. <i>Community health environment checklist [CHEC]</i> [10]	10. Valid measure; use of two fingers (force to be applied) to open a door; use of a fist, without wrist torsion, to operate door handles
Educational and leisure infrastructures	
11. <i>Greater Toronto Hotel Association hospitality accessibility checklist</i> [11]	11. Call-bell/bidirectional communication device near accessible parking spaces; door handle on the left side of the door when it pivots towards the opener (reduce the risks of injuring guide dogs or the number of manipulations for the handler to perform); learning and leisure infrastructures (conference rooms and many items related to school environments)
12. <i>Physical accessibility measure for schools [PAMS]</i> [12]	12. Canadian measure of school environments used to develop the <i>UCAM</i>
13. <i>University campus accessibility measure [UCAM]</i> [13]	13. Canadian measure concerned with school environments for people with mobility impairments; cross-slope of sidewalks (1:40); avoid complex flooring motifs (confusing to people with a visual disability); smooth wall surfaces (avoid injuries when people use walls to locate themselves); minimal dimensions for lifts (1525 mm x 1525 mm) and the height of the gate (1065 mm)

2.2 Content development of the MAUAP (step 2)

A first draft of the measure was developed with the results obtained from step 1. Initially, all environmental variables and subvariables found in the literature related to fair access for individuals with various physical disabilities using assistive devices were listed (see table 2). Then, all criteria used to assess them, in both the scientific and grey literature, were compiled and compared by the first author of the measure (SG). Only those proposing the most severe accessibility measures were first selected to develop the measure, for the formulation of items and characteristics, regardless of their provenance.

Four different levels of content were identified in the measure. The first level presents the environmental *variables*, namely the seven types of urban infrastructures evaluated or sections of the MAUAP (e.g. 1- *Parking lot* [as seen in appendix 1]). The second level refers to *subvariables*, which are the exterior and interior subvariables detailed in table 2 that are present within the environmental variables evaluated with the measure (e.g. *Parking meter in section 1*). The third level refers to the *items*, which are affirmative sentences related to signage, accessibility

(space and usability), safety and specific equipment (if any) for each subvariable (e.g. 1.8- *The signage for the use of the parking meter is accessible* [as seen in appendix 2]). Items are checklists of characteristics. The fourth and final level of content to consider includes the *characteristics*, i.e. the observable and quantifiable aspects defining the environments evaluated. They are as objective as possible and were identified through the literature review process (step 1) (e.g. 1.8, *first checkbox: Parking meter located in a well-lit place (200 lux or more)* [as seen in figure 2]).

For scoring, since items are presented as checklists of characteristics, it was proposed that the evaluator check each characteristic if present, and otherwise leave it unchecked. To further characterise the degree or level of accessibility, the evaluator computes the percentage of characteristics present per item, and attributes an accessibility score on a 4-level rating scale of accessibility, based on percentage ranges of checked characteristics. Since the number of characteristics per item varies, a rating scale with fewer levels would not have been useful for discrimination purposes, and a rating scale with more levels would have given statistically insignificant rating

levels for items with fewer characteristics. Since there is limited knowledge to properly assign weighting factors to environmental characteristics which target diversified populations, it was deemed better to consider all items and characteristics as being equally important.

2.3 Content validation of the measure (step 3)

Content validity examines the degree to which an instrument represents the universe of concepts or domains it is intended to measure; whether the instrument adequately samples the content of a construct [29,30]. Usual notions about content validity and the process of content validation are described as they pertain to the following four concepts: domain sampling, domain relevance, domain clarity, and technical quality in test items [31].

Following the literature review described above (step 1), to further ensure content validity, experts concerned with the subject in question were consulted in focus groups or individual interviews [29]. The experts evaluated 'domain relevance' by answering the following question for each item: "Is the skill or knowledge measured by this item 'essential,' 'useful, but not essential,' or 'not necessary' to the

performance of the construct?" Experts were also asked if they considered the criteria presented in the items and characteristics to be applicable. If more than half the panelists indicate that an item is essential, that item has at least some content validity [32]. The first panel of experts consisted of the five researchers who co-authored this paper, including the principal investigator (CV). They have complementary expertise, as reported in table 4. Seven three-hour pre-test meetings, one meeting for each MAUAP section, were held. At each meeting, the master's candidate student on the project (SG), also an occupational therapist, presented the field testing performed for each section with pictures and videos of urban built environments to the researchers as well as items and characteristics for the evaluation of these environments. In the first meeting, the researchers analysed and pretested the first section using the pictures/videos, the ultimate goal being the conceptualisation and operationalisation of the definition of accessibility criteria within the measure. All the researchers independently rated the environments and presented their resulting ratings. They then discussed the results until they reached an agreement on better content formulation. They also discussed what to plan for the development of the next section. At the second meeting, the

modifications made to section one were discussed and validated for final changes. The researchers also analysed and pretested the second section. This process was repeated for all sections of the MAUAP. The rating scale and formatting of the measure were also discussed during the meetings and a consensus was reached. Moreover, the introduction and presentation of the measure were discussed at the final meeting to ensure good comprehension of the instructions. The modified measure was submitted to the researchers for a final review. The consultation process with the first panel of experts took place over a period of seven months.

As for 'domain clarity' and 'technical quality in test items' [31], consultations were held with a second panel of experts to confirm the exhaustiveness of the content of the measure with respect to accessibility and the usability of the rating scale. The second panel of experts included representatives of the community, municipal and health sectors. Seven individuals representing five organisations defending the rights of people with different physical disabilities using assistive devices or not, two health clinicians and five professionals in the field of urban planning and architecture

were consulted. Twelve were met in four focus groups and two in individual interviews (n=14). They were recruited for their interest in accessibility of urban infrastructures and for their sectoral and complementary points of view regarding accessible built environments (see bottom of table 4 for the experts' backgrounds).

They all received the complete measure a month before the scheduled meeting and were asked to comment on the content and structure of the MAUAP. With respect to content, the following points were addressed: the content and wording of the seven sections' variables, subvariables, items and characteristics. As for structure, the following subjects were discussed: content and presentation of the introduction, sections and appendices, computation of the percentage of characteristics present and its translation to the 4-level rating scale. The moderator, the principal investigator (CV), used the same interview protocol for each consultation. To ensure all the elements discussed, the meetings were recorded. After presentation of the subjects to be discussed (i.e. introduction section explaining the use of the MAUAP as well as its seven sections), the participants presented their suggestions in turn. The co-moderator, the master student (SG), answered participants'

questions regarding the measure and its development and noted their suggestions. The proposed modifications were added to the measure and the amended version was sent to the community, municipal, and health representatives a month after the last meeting. They then had a month to forward final comments to finalise the experimental version. The consultation process with the

second panel of experts took place over a period of two months. This version of the MAUAP was pretested in the field for each section. The master student, the first author (SG), identified inconsistencies between what could really be observed and objectively rated, and proposed the final adjustments to the text to facilitate the rating.

Table 4. Consulted experts' background

Researchers' background (1st panel of experts)				
Role	Academic training	Last graduate diploma	Field of research	n = 5
Researcher	Occupational therapy	Ph.D. in public health	Assistive technology assessment with mobility impaired, blind and deaf individuals as well as elderly	CV
Researcher	Kinesiology	Ph.D. in biomechanics	Locomotor control, gait and obstacles with mobility impair	BJM
Researcher	Mechanical engineering	Ph.D. (rehabilitation sciences)	Assistive technology, wheelchair users, social participation, spinal cord injury, older adults	FR
Researcher	Psychology	Ph.D. in social services	Social and community support of people presenting a spinal cord injury	LB
Research assistant	Sociology	M.A. in urban planning	Environmental factors and social participation of people with disabilities	DF
⁴ Graduate student	Occupational therapy	M.Sc. student (rehabilitation sciences)	Urban accessibility assessment	SG
Community, municipal, and health representatives' background (2nd panel of experts)				
Field of practice	Status or title			n = 14
Organisations defending people with physical disabilities' rights	People living with motor impairments (n = 2) ¹			7
	Deaf and hearing-impaired people (n = 3) ²			
	Visually impaired people (n = 1) ³			
	People living with visual and hearing impairments (n = 1)			
Professionals of urban planning and architecture	Transport technician (n = 1)			5
	Landscape architect (n = 1)			
	Architects (n = 2)			
	Research officer in leisure, sports and community life (n = 1)			
Health clinicians	Occupational therapist (n = 1)			2
	Orientation and mobility specialist (n = 1)			

¹ One is a scooter user. ² One uses the Quebec sign language. ³ One uses a white cane. ⁴ SG was not a researcher. Her role in the panel was to collect data and present it to the panel

3. Results

The experimental version of the MAUAP was initially developed in French and translated into English (see [33] for WEB links). It includes an introduction presenting the objective, use, concepts underlying the measure, instructions for users, as well as the required material and a rating example. This is followed by the seven sections (see appendix 1) with 133 objective items, which follow the logical chronological order of the use of the environment (signage, accessibility, safety, equipment (if any)). The section names with number of items in each are as follows: Parking lot: 11 items, Pedestrian facilities: 11 items, Building access from the exterior: 17 items, Interior maneuvering areas: 12 items, Infrastructures for learning (educational) and leisure: 33 items, Services: 26 items, and Public restroom with and without stalls: 23 items. In certain items, key points identified with the experts consulted are shown in bold; for example, in figure 2, Parking lot, item 1.1, 2nd characteristic: *Presence of a standardised sign clearly indicating the accessible parking space (key point)*. These key points are characteristics without which accessibility would be impossible or greatly hindered and that need to be analysed with great care; no weighting factor is present to put

more emphasis on them, as explained earlier, since no information could be found regarding the relative importance of accessibility criteria identified in the literature. The MAUAP also includes appendices, comprising a glossary, conversion tables for angles and proposed criteria for the evaluation of stairs. Since stairs are not universally accessible structures (wheelchair users and individuals with severe mobility impairments do not normally use them), their evaluation was not formally included in this measure and they were not included in the validation process of the measure. However, since some individuals with various physical disabilities using mobility assistive devices (e.g. cane, walker) use them, characteristics are proposed. Finally, a table indicating appropriate combinations of contrasting colours for individuals with visual limitations is presented.

In the MAUAP, each variable (section), subvariable and item is independent and can be evaluated as such; however, no global score can be calculated. The scoring system needs to be considered from three angles. Firstly, the items' characteristics left unchecked visually indicate which environmental problems are present and need to be addressed. Secondly, the percentage of

checked characteristics per item allows for a more comprehensive appreciation of the accessibility level of the environment in relation to signage, accessibility, safety, and specific equipment (if any). According to the percentage of checked-off characteristics, the evaluator attributes a level of accessibility using a 4-level ordinal scale. Either the item is not present or 0% of the characteristics are present (1: Not present or 1: Inaccessible), under 50% of the characteristics are present (2: Poor to moderate accessibility), 50% or more of the characteristics are present (3: Moderate to excellent accessibility), or 100% of the characteristics are present (4: Exemplary accessibility). These categories were identified to ensure that all accessibility

levels in the rating scale would have a statistically significant result for all items (3 to 16 characteristics). In the first example in figure 2, 'Section 1, Parking lot, item 1.1 *The signage is accessible*', the evaluator checked 3 of the 5 boxes (characteristics), which is converted into a percentage (60%) to attribute a rating of 3: Moderate to excellent accessibility (meaning 50% or more of the characteristics are present). Finally, to analyse the level of accessibility properly, comments noted by the evaluator need to be considered. Lack of consideration of any of these three aspects could result in a misunderstanding of the problems and opportunities that the environment offers.

1- Parking lot


		Accessibility				
		1- Not present	1- Inaccessible 0 % accessible	2- Poor to moderate < 50 % accessible	3- Moderate to excellent 250 % accessible	4- Exemplary 100 % accessible
In the absence of an accessible parking space, indicate 3 points in the not present box and go to the indications preceding item 1.4 to evaluate the route leading to a Parking meter (1.8) OR to a Ticket machine or a toll station (1.10) depending on the nature of the equipment present.						
PARKING LOT (specify where : _____)						
1.1 The signage is accessible <input checked="" type="checkbox"/> Surface of the accessible parking space is blue and delimited by white lines 100-150 mm wide With the international pictogram of accessibility in the center With a hatched drop-off zone <input checked="" type="checkbox"/> Presence of a standardized sign clearly indicating the accessible parking space (key point) <input type="checkbox"/> Sign visible and lit (200 lux or more) With contrasting background and writing (70 %) With a character size of 22 mm or more Simple characters sans serif (verdana, arial, frutiger) Essential message (avoid sentences) <input checked="" type="checkbox"/> Vertical allowance under the sign of 2100 mm or more <input type="checkbox"/> Access route(s) for pedestrians marked with yellow diagonal lines		Comments : Rating : 1 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input checked="" type="checkbox"/> 4 <input type="checkbox"/>				
1.2 The accessible parking space is accessible <input type="checkbox"/> Minimal number of accessible parking spaces required If there are 25 parking spaces of less , 1 space or more is accessible OR If there are more than 25 parking spaces , 2 % or more of the spaces are accessible <input checked="" type="checkbox"/> Presence of an accessible parking space near all accessible entrances (or to an elevator for interior parking) (key point) <input type="checkbox"/> Accessible parking space of rectangular shape, parallel to the drop-off area <input type="checkbox"/> Dimensions of the accessible parking space : (key point) If it is a single accessible parking space Width of 4600 mm or more (3 m for the vehicle and 1600 mm for the drop-off area) Length of 5500 mm or more OR If there are two reserved adjoining spaces Width on each side of 3 m for the vehicle and of 1800 mm for the common drop-off area that is free from obstacles Length of 5500 mm or more <input checked="" type="checkbox"/> Level continuous surface including the accessible parking space and the drop-off area If it is interior parking, add : <input type="checkbox"/> Clearance height of 2750 mm or more for the entire route <u>from the access to the exit (in vehicle)</u> <input type="checkbox"/> Clearance height of 2300 mm or more <u>above the accessible parking space</u>		Comments : Rating : 1 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input checked="" type="checkbox"/> 3 <input type="checkbox"/> 4 <input type="checkbox"/>				
1.3 The accessible parking space is safe <input checked="" type="checkbox"/> Route leading to the building does not necessitate circulation behind other vehicles <input checked="" type="checkbox"/> Drop-off area not included in the area where vehicles circulate (if the accessible parking space is not large enough and that the drop-off area spills out into another parking space or into an area where vehicles circulate, do not check off this box) <input checked="" type="checkbox"/> Ground surface firm and slip resistant even if wet <input checked="" type="checkbox"/> Uniform lighting, continuous and non blinding on the accessible parking space and the drop-off area (50 lux or more with luminous transitions of 300 lux or less) If it is interior parking, add : <input checked="" type="checkbox"/> Non obstructed vision or presence of convex mirrors where vision is obstructed <input checked="" type="checkbox"/> Presence of a call-bell or a bidirectional communication device located near the accessible space(s)		Comments : Rating : 1 <input type="checkbox"/> 1 <input type="checkbox"/> 2 <input type="checkbox"/> 3 <input type="checkbox"/> 4 <input checked="" type="checkbox"/>				

Figure 2. Rating examples of three of the MAUAP's items including signage, accessibility and safety concerns

4. Discussion

The development of the first version of the MAUAP is now complete and its content validity has been established. An exhaustive review of the scientific and grey literature (step 1) preceded the

development of an initial draft of the measure (step 2). Content validity was then ensured through the involvement of two panels of experts (1: researchers with specific expertise in the field of rehabilitation, and 2: representatives of the community, municipal, and health sectors

(some using assistive technologies for mobility [scooter, white cane, hearing aids]) as well as through the pretesting of each section of the measure in the field to evaluate its coherence and the usefulness of the rating scale (step 3).

When compared with other measures found in the literature, the MAUAP 4-level rating scale, based on the percentage of accessible characteristics present, should allow better discrimination between different levels of accessibility. Contrary to the MAUAP, 10 of the measures used to develop it (see table 3) have dichotomous scales, while three other measures combine different rating scales. In the MAUAP, the rating scales are the same across all items for uniform consideration of all individuals and environmental characteristics concerned. This guarantees uniformity in the way information is collected, which is important when only one variable is considered in a measure [34].

The MAUAP has many advantages over the 13 measures identified as relevant for the development of an accessibility measure. For example, the Community Health Environment Checklist (CHEC), a valid measure well suited for the practice of rehabilitation professionals [35], has 65 items which are mostly related to the MAUAP variables (sections). The advantage of the MAUAP over the CHEC is the consideration of complementary

types of urban built environments such as exterior as well as interior infrastructures (e.g. intersection leading to a school as well as the characteristics required to access the school's premises: library, auditorium, classrooms, dressing room, lockers, showers, cafeteria, snack bar, ATM). Moreover, the environmental characteristics of the built environment evaluated by the MAUAP are observable and quantifiable. For example, in the CHEC, item 45 is the only item where adequate lighting is addressed: *"Is there adequate lighting to see the stair steps or obstacles in the path of travel?"*, with the option to check: *"Yes if there is enough lighting to read this paper (black print on white paper) without squinting"*. In the MAUAP, adequate lighting is addressed in various places and is measured with a luxmeter, such as in the following example in item 1.3: *"☐ Uniform lighting, continuous and non-blinding on the accessible parking space and the drop-off area (50 lux or more with luminous transitions of 300 lux or less)"*. Also, the MAUAP considers not only wheelchair users, but also the impact of most mobility, hearing and visual impairments. It theoretically allows the consideration of each population's needs and of environmental elements facilitating or hindering access for all individuals with physical impairments.

When compared with the Curb ramp accessibility measure [36] and the Walking Route Audit Tool for Seniors [37], the advantage of the MAUAP is that it not only addresses exterior access, it also evaluates interior access. Moreover, the 11 other measures identified as relevant for the development of an accessibility measure only consider access from the parking lot to interior access [35,38-47]. The combination of the pedestrian and the building's exterior access in the MAUAP allows an exhaustive evaluation of all possible ways of getting to and into a building. It also specifically evaluates access to learning (educational) and leisure infrastructures. It does so from a perspective not of universal design but of making sure that the existing built environment is accessible to individuals with physical disabilities. Learning (educational) and leisure infrastructures are only evaluated by three measures presented in table 3, the Greater Toronto Hotel Association hospitality accessibility checklist [41], the Physical Accessibility Measure for Schools (PAMS) [46], and the University Campus Accessibility Measure (UCAM) [47]. Overall, the MAUAP is a more comprehensive and exhaustive measure of accessibility to the built environment of exterior and interior urban infrastructures for adults with different physical disabilities. Because the MAUAP is the result of combining all pertinent

accessibility criteria present in other accessibility measures, its content is different from those measures. Construct validity was not evaluated since there is no comparable measure which could be used as a gold standard.

This study has some limitations, mainly related to the measure's external validity. All the researchers and experts consulted had lived in Quebec City for many years. This could have influenced their opinion of physical obstacles encountered in the city. Quebec City (~ 500 000 inhabitants excluding the suburbs) might not present all types of possible obstacles and environmental variables found in urban infrastructures (e.g. metro or subway access). Even though the MAUAP is mainly based on Canadian standards, the literature review was international, and the measure could be used in other countries with different construction codes and norms. In fact, the MAUAP's characteristics could be modified to accommodate other countries' norms. No total score for the entire tool can be given due to the absence of any relationship between the items within the sections (e.g. library and phone). Using an urban public environment requires access for the entire route as well as use of the infrastructures; a global score would need to be calculated according to the specific use one makes of the environment.

Moreover, depending on needs, the evaluator could target only specific sections and subsections. The use of the electronic version can also be very useful, especially when compiling evaluations.

This paper was specifically designed to describe the development and content validation process of the MAUAP. Since it was pretested in the field only by an occupational therapist, future research should consider the MAUAP's usability by different professionals (e.g. architects, stakeholders, users). Content with regard to parks, swimming pools, people presenting intellectual and cognitive limitations, and using a scooter in interior environments should also be considered in future versions to further meet the goal of accessibility for all.

5. Conclusion

The MAUAP allows the identification of precise accessibility recommendations that can be useful for professionals concerned with accessibility to urban infrastructures and individuals with various physical disabilities using assistive devices or not in order to facilitate their social participation. This measure can be used to evaluate the accessibility level of urban environments (pedestrian, learning and leisure infrastructures) and

identify problematic architectural characteristics with a structured consideration of the environment. It also proposes observable and measurable solutions that may facilitate communication between clinicians, individuals with mobility impairments, and construction professionals. The introduction, the chronological structure according to the environment's functional use, and the detailed characteristics all facilitate use of this measure. Finally, the objectivity of all items, the accessibility ratings and the possibility of providing comments allow both global and specific evaluations of the environment.

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APPENDIX 1. Items included in each section of the *MAUAP*

Items from section 1 : Parking lot

- 1.1 The signage is accessible
- 1.2 The accessible parking space is accessible
- 1.3 The accessible parking space is safe
- 1.4 The curb cut or the sloped curb leading to the surface on which the parking meter, ticket machine or toll station is placed is accessible
- 1.5 The curb cut of the sloped curb leading to the surface on which the parking meter, ticket machine or toll station is placed is safe
- 1.6 The surface on which the parking meter, ticket machine or toll station is placed is accessible
- 1.7 The surface on which the parking meter, ticket machine or toll station is placed is safe
- 1.8 The signage for the use of the parking meter is accessible
- 1.9 The parking meter is accessible
- 1.10 The signage for the use of the ticket machine or the toll station is accessible
- 1.11 The ticket machine or the toll station is accessible

Items from section 2 : Pedestrian facilities

- 2.1 The curb cut or the sloped curb to access the sidewalk is accessible
- 2.2 The curb cut or the sloped curb to access the sidewalk is safe
- 2.3 The sidewalk or the pedestrian path is accessible
- 2.4 The sidewalk or the pedestrian path is safe
- 2.5 The curb cut or the sloped curb to leave the sidewalk is accessible
- 2.6 The curb cut or the sloped curb is safe
- 2.7 The pedestrian traffic light is safe
- 2.8 The crosswalk is accessible
- 2.9 The crosswalk is safe
- 2.10 The curb cut or the sloped curb to access the sidewalk after crossing the street is accessible
- 2.11 The curb cut or the sloped curb to access the sidewalk after crossing the street is safe

Items from section 3 : Building access from the exterior

- 3.1 The curb cut or the sloped curb to access the sidewalk leading to the building's entrance is accessible
- 3.2 The curb cut or the sloped curb to access the sidewalk leading to the building's entrance is safe
- 3.3 The sidewalk or the pedestrian path to access the building is accessible
- 3.4 The sidewalk or the pedestrian path to access the building is safe
- 3.5 The layout of the ramp leading to the building is accessible
- 3.6 The ramp leading to the building is safe
- 3.7 The exterior signage is accessible
- 3.8 The entrance door is accessible from the exterior
- 3.9 The entrance door is functional and safe (entrance)
- 3.10 The entrance door is functional and safe (exit)
- 3.11 The vestibule is accessible and safe
- 3.12 The floor, the walls and the lighting of the vestibule are safe
- 3.13 The interior vestibule door is accessible from inside the vestibule (entrance of the building)
- 3.14 The interior vestibule door is functional and safe (entrance)

- 3.15 The interior vestibule door is functional and safe (exit)
- 3.16 The interior vestibule door is accessible from outside the vestibule (exit of the building)
- 3.17 The entrance door is accessible from inside

Items from section 4 : Interior maneuvering areas

- 4.1 The global signage for the building is accessible
- 4.2 The floor, the walls and the lighting are safe
- 4.3 The hallway is accessible and safe
- 4.4 The environmental control is accessible
- 4.5 The layout of the ramp is accessible
- 4.6 The ramp is safe
- 4.7 The exterior of the elevator is accessible
- 4.8 The interior of the elevator is accessible
- 4.9 The elevator is safe
- 4.10 The exterior of the platform lift is accessible
- 4.11 The interior of the lift is accessible
- 4.12 The platform lift is safe

Items from section 5 : Infrastructures for learning and leisure

- 5.1 The signage of the classroom, meeting room, multipurpose room, community hall or auditorium is accessible
- 5.2 The classroom, meeting room, multipurpose room, community hall or auditorium door is accessible from outside
- 5.3 The classroom, meeting room, multipurpose room, community hall or auditorium room is functional and safe
- 5.4 The classroom, meeting room, multipurpose room, community hall or auditorium door is accessible from inside
- 5.5 The floor, the walls and the lighting in the classroom, meeting room, multipurpose room, community hall or auditorium are safe
- 5.6 The environmental controls of the classroom, meeting room, multipurpose room, community hall or auditorium are accessible
- 5.7 The classroom, meeting room, multipurpose room, community hall or auditorium is accessible
- 5.8 The general signage of the library / resource centre is accessible
- 5.9 The library or resource centre door is accessible from outside
- 5.10 The library or resource centre door is functional and safe (entrance)
- 5.11 The library or resource centre door is functional and safe (exit)
- 5.12 The library or resource centre door is accessible from inside
- 5.13 The floor, the walls and the lighting of the library or the resource centre are safe
- 5.14 The environmental controls in the library / resource centre are accessible
- 5.15 The library / resource centre's bookshelves are accessible
- 5.16 The shelves are accessible
- 5.17 The reception desk is accessible
- 5.18 The computer station or work station is accessible
- 5.19 The locker room door is accessible from outside
- 5.20 The locker room door is functional and safe
- 5.21 The locker room door is accessible from inside
- 5.22 The signage of the dressing room is accessible
- 5.23 The opening and closing mechanism of the dressing room door is functional
- 5.24 The floor, the walls and the lighting of the dressing room are safe

- 5.25 The dressing room is accessible
- 5.26 The dressing room is safe
- 5.27 Some lockers are accessible
- 5.28 The signage of the shower stall is accessible
- 5.29 The opening and closing mechanism of the shower stall door is functional
- 5.30 The floor, the walls and the lighting of the shower stall are safe
- 5.31 The vestibule leading to the shower is accessible and safe
- 5.32 The shower stall is accessible and safe
- 5.33 The components of the shower stall are accessible

Items from section 6 : Services

- 6.1 The building has security devices that are functional and accessible
- 6.2 The reception desk is accessible
- 6.3 The signage of the service is accessible
- 6.4 The door is accessible from outside
- 6.5 The door is functional and safe
- 6.6 The exit door is functional and safe
- 6.7 The door is accessible from inside
- 6.8 The environmental control is accessible
- 6.9 The signage of the area with chairs and tables is accessible
- 6.10 The floor, the walls and the lighting of the area with chairs and tables are safe
- 6.11 The area with chairs and tables is accessible
- 6.12 The signage of the cafeteria / snack bar is accessible
- 6.13 The floor, the walls and the lighting of the cafeteria / snack bar are safe
- 6.14 The cafeteria / snack bar is accessible
- 6.15 The cafeteria or snack bar menu is accessible
- 6.16 All of the dispensers are accessible (e.g. coffee machines, juice fountains)
- 6.17 All of the food is accessible (food or service utensils)
- 6.18 All of the utensils and the dishes/plates are accessible
- 6.19 Ordered food is accessible
- 6.20 The cashier's counter is accessible
- 6.21 The equipment is accessible
- 6.22 The phone is accessible
- 6.23 The equipment is accessible (water fountain)
- 6.24 The water fountain is accessible
- 6.25 The equipment is accessible (automatic teller machine)
- 6.26 The automatic teller machine is accessible

Items from section 7 : Public restroom

Public restroom with stall(s)

- 7.1 The signage of the restroom is accessible
- 7.2 The restroom door is accessible from outside
- 7.3 The restroom door is functional and safe
- 7.4 The restroom door is accessible from inside
- 7.5 The floor, the walls and the lighting in the restroom are safe
- 7.6 The environmental controls in the restroom are accessible
- 7.7 The layout of the stall allows access to the toilet
- 7.8 The opening and closing mechanism of the stall door is functional
- 7.9 The grab bars in the stall are accessible
- 7.10 The toilet's components are accessible

7.11 The counter is accessible to use the sink

7.12 The elements necessary to wash hands and to look at oneself are accessible

Public restroom without stall

7.13 The signage of the restroom is accessible

7.14 The restroom door is accessible from outside

7.15 The restroom door is functional and safe

7.16 The restroom door is accessible from inside

7.17 The floor, the walls and the lighting of the restroom are safe

7.18 The environmental controls in the restroom are accessible

7.19 The layout of the restroom allows access to the toilet

7.20 The grab bars in the toilet without stalls are accessible

7.21 The toilet's components are accessible

7.22 The counter is accessible to use the sink

7.23 The elements necessary to wash hands and to look at oneself are accessible