Defining the built environment considering people with disabilities: Building a Canadian-focused database of anthropometric space requirements

Final Report:
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Executive summary

The overarching goal of this project was to generate a Canadian-focused evidence base on the static and functional space requirements and operating control installation heights of mobility assistive device users, with the intent of informing the development and revision of accessibility codes and standards for the Canadian built environment. The work responds to the need for empirical, updated Canadian data to guide inclusive design practices that reflect the real-world dimensions, maneuverability, and functional capacities of mobility assistive device users.

Four specific aims guide the project. ***Aim 1*** was to develop a comprehensive database of functional space requirements and operating control installation parameters for Canadian adult wheeled mobility device (WhMD) users. ***Aim 2*** explored the lived experiences of individuals who use WhMDs in Canada, with particular attention to how spatial design influences maneuverability, lived experiences, and use of public environments. ***Aim 3*** summarized the current state of knowledge related to design recommendations for children who use WhMDs. ***Aim 4*** synthesized study findings into a set of evidence-informed recommendations to improve accessibility in the Canadian built environment.

Over a 2 year data collection period, data were collected from 222 assistive device users, across different mobility groups, including manual wheelchair users, power wheelchair users, mobility scooter users, walker/rollator users, and individuals travelling with guide dogs. While we collected data from the above described groups, the primary focus of our analysis was WhMD users, as they generally drive the largest space requirements, and therefore represent a critical reference population for accessibility standards development. However, our recommendations were developed to ensure that other user groups would not be negatively impacted or unintentionally excluded as a result of the recommended space requirements.

For the laboratory component of this project, we collected static measurements (e.g. device and user dimensions) and functional measurements (e.g. turning areas, reaching tasks) of users with their devices. Data are reported from our collected dataset, along with statistical estimates based on population-level distributions of devices in Canada. Our results are compared with current Canadian accessibility codes and standards, with recommendations based on inclusion of the 95th percentile of WhMD users in Canada. In addition to quantitative laboratory measures, lived-experience data (collected through interviews with WhMD users) highlight how space designs affect independence, safety, and usability in public spaces. Finally, although primary data collection focused on adults, this project also synthesized available evidence to inform guidance for spaces where considerations for children should be made.

Overall, this project provides a robust, Canadian-focused evidence base to support accessibility codes and standards development. By integrating static measurements, functional performance data, and lived experience perspectives, the findings offer evidence-informed recommendations to enhance the accessibility, usability, and inclusivity of the built environment for Canadians with disabilities. The data can support harmonization across existing

standards and building codes, reduce barriers, and promote inclusive design. Beyond buildings and public spaces, these findings may be used to inform the design of transportation systems, products and furniture. Applying this evidence broadly will help ensure that both environments and the products people rely on are safe, functional, and inclusive for people with disabilities.

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1. Introduction

Anthropometry refers to the measurement of human body size, shape, and functional capacity. In the design of the built environment, anthropometric data serve as a foundation for defining space requirements that safely and effectively accommodate end users. Design standards often prioritize the largest space requirements, which typically reflect the needs of individuals who use wheeled mobility devices (WhMD). For these users, measurements must account for the individual, their mobility device or aid, and the functional movements required for use, such as reaching and maneuvering. However, barrier-free design must also address the needs of other users, including individuals who rely on different forms of assistance or aids to safely navigate their environments.

Accessible built environments are essential to enabling participation, independence, and inclusion. While built environment accessibility benefits all Canadians, it is particularly critical for individuals who require on mobility aids such as canes, walkers, and wheelchairs, as well as those with visual, auditory, or balance-related impairments. Access to community infrastructure supports independence, social participation, and active living, which are associated with improved health and well-being (Clarke, Ailshire, Bader, Morenoff, & House, 2008; Clarke, Ailshire, & Lantz, 2009; Hirsch, et al., 2014; Kim & Clarke, 2015; Bowling, Barber, Morris, & Ebrahim, 2006; Fratiglioni, Paillard-Borg, & Winblad, 2004; Greaves & Farbus, 2006). Appropriately defined and applied accessibility standards are therefore foundational to ensuring equitable participation in public spaces for people living with current or future disabilities. Consistent with national priorities, built environment barriers have been identified as a leading concern among Canadians with disabilities (Lau, et al., 2020) underscoring the need for robust, evidence-informed standards.

1.1. Prevalence of mobility devices

In establishing the space requirements in accessibility codes and standards, particular attention is often given to users with the largest space needs, including individuals who use WhMDs such as manual wheelchairs, powered wheelchairs, and scooters. According to the 2012 Canadian Survey on Disability (CSD), it was estimated that roughly 288,800 individuals used a wheelchair or scooter (Smith, Giesbrecht, Mortenson, & Miller, 2016), while approximately 465,340 used a walker (Charette, Best, Smith, Miller, & Routhier, 2018). New CSD data was released in 2022, enabling an updated summary of mobility device use among individuals who reported a mobility disability and used one or more of the selected mobility aids (walker, manual wheelchair, power wheelchair, scooter; individuals could report multiple devices). This analysis conducted by our research team is summarized in Table 1 below, with prevalence estimates presented for individuals aged 15 years and older, and separately for those aged 65 years and older.

Table 1. Mobility device use among Canadians, summary of data from the Canadian Survey on Disability (2022) from Statistics Canada

Age Group		Prevalence of Mobility Devices, 2022 (%)				
		All Device Users	Walker	Scooter	MWC	PWC
15 years and over	Total, All Gender	860,240 2.9%[a]	707,260 2.4%[a]	121,420 0.4%[a]	201,950 0.7%[a]	51,650 0.2%[a]
	Men	303,430 2.1%[b]	225,060 1.6%[b]	60,570 0.4%[b]	80,380 0.6%[b]	24,940[c] 0.2%[b]
	Women	556,820 3.7%[b]	482,200 3.2%[b]	60,850 0.4%[b]	121,570 0.8%[b]	D 0.2%[b]
65 years and over	Total, All Gender	602,050 9.7%[b]	531,340 8.5%	71,580 1.2%	121,980 2.0%	23,490[c] 0.4%
	Men	195,280 6.8%[b]	158,090 5.5%[b]	43,910[c] 1.5%[b]	42,930 1.5%[b]	D 0.3%[b]
	Women	406,770 12.2%[b]	373,260 11.2%[b]	27,680[c] 0.8%[b]	79,050 2.4%[b]	D 0.4%[b]

MWC, manual wheelchair; PWC, power wheelchair
[a]*Proportion of Canadians aged 15 years or over.*
[b]*Proportion of respondents in age group.*
[C] *Use with Caution. D Too unreliable to publish, as reported by Statistics Canada, 2022*

Mobility device usage has increased since 2012. As Table 1 shows, among community-dwelling Canadians aged 15 years or older, there were approximately 860,240 (95% CI=807,610; 911, 220) individuals who used at least one of the selected mobility aids (i.e. walker, scooter, manual wheelchair, power wheelchair) in 2022, representing 2.9% of the total population. Of these individuals, 64.7% identified as women and 70% were over the age of 65 years.

Within mobility aid users, 707,260 (95% CI=658,780; 756, 040) used a walker, 121,420 (95% CI=101,040; 143, 570) used a scooter, 201,950 (95% CI=178,140; 228, 020) used a manual wheelchair (MWC), and 51,650 (95% CI=39,110; 65, 560) used a power wheelchair (PWC). Individuals over the age of 65 years accounted for 45.5% of PWC use, 59% of scooter use, 60.4% of MWC use, and 75.1% of walker use within each mobility aid category. Among the types of WhMDs used, 53.9% of devices were manual wheelchairs, 32.4% were mobility scooters, and 13.8% were power wheelchairs (Statistics Canada, 2022).

1.2. Canadian accessibility standards related to the built environment

Accessibility standards related to the built environment in Canada have evolved significantly over the past decades. Technical accessibility requirements have existed in the National Building Code of Canada (NBCC) since 1980 and have been progressively expanded and refined in subsequent editions. Within the NBCC, accessibility provisions are primarily located in

Section 3.8 (Barrier-Free Design). As a model code, the NBCC establishes minimum requirements for safety and access.

As a widely recognized resource, Canadian Standards Association (CSA) has provided a national voluntary technical standard for barrier-free design of the built environment since 1990. While there is increasing alignment between the NBCC and CSA standards, CSA B651 provides detailed technical guidance and may exceed NBCC minimum requirements. In 2019, the passing of the Accessible Canada Act and the establishment of Accessibility Standards Canada (ASC), led to the development of new standards across Canada. In 2021, ASC announced its collaboration with the Canadian Standards Association (CSA), followed up with a joint release of the sixth edition of the Canadian National Standard for *Accessible design for the built environment* (CSA/ASC B651:23) in 2023.

1.3. Evidence guiding the development of accessibility requirements for the built environment

To inform the space requirements in accessibility standards, many Canadian codes and standards have relied on a decades-old database of US-based anthropometric measurements of adult WhMD users to guide defined indoor and outdoor space requirements of the built environment (Steinfeld, Paquet, D'Souza, & Maisel, 2010). For example, CSA/ASC B651:23 generally considers designs based on performance of the 95th percentile of WhMD users included in this dataset; other codes and standards rely on this available data, though are guided by other considerations (e.g. inclusion of 90th percentile of WhMD users in NBCC 2025). While a substantial number of devices were evaluated to establish static dimensions (e.g., occupied length and width), far fewer were assessed for maneuverability space (e.g. for performing a 180-degree turn). Importantly, scooter users were minimally represented in the functional testing sample, which was heavily weighted toward manual wheelchair users. More recent studies in Australia (Caple, Morris, Oakman, Atherton, & Herbstreit, 2014) and the United Kingdom (Atkins-Jacobs Joint Venture, 2021; ARUP Consultants, 2022) have also examined the spatial requirements of WhMD users, though to date, Canadian-specific data concerning WhMD maneuverability is lacking.

While expanding the scope of WhMD types is necessary to ensure the built environment spaces meet the needs of people using such devices, to ensure a universal design approach, consideration of other users of the space (beyond WhMD users) is necessary. For example, people who travel with a sighted guide or guide dog may require additional width along a barrier-free path of travel, yet there is currently limited empirical data to inform these spatial requirements. Similarly, individuals who use walkers/rollators may have reduced reach capacity due to stability demands, which may influence how they interact with elements of the built environment.

Developing an updated, Canadian-focused anthropometric database is required to better inform standards development across the country and help ensure that spatial requirements accurately reflect the diversity of users. This would support efforts to harmonize recommendations across existing standards and building codes, remove barriers, and promote inclusive design in the built environment. Updated data could inform not only accessibility standards for buildings and public spaces, but also the design of transportation systems, healthcare and recreational environments, emergency evacuation plans, assistive technologies, mobility devices, and accessible vehicles, as well as related products such as scooters, wheelchairs, grab bars, or furniture. By applying this evidence across these areas, the dataset can help ensure that both the environments and the products people require are safe, usable, and inclusive for all mobility device users.

2. Project objectives and approach

The overarching goal of this project was to generate a Canadian-focused evidence base on the static and functional space and operating control installation requirements of mobility assistive device users, with the intent to guide the development and revision of accessibility codes and standards for the built environment. Focusing on four specific aims helped to achieve the project goal:

Aim 1: To develop a database of functional space and operating control installation requirements from Canadian adult wheeled mobility device (WhMD) users.
Aim 2: To explore the lived experience of people who use WhMDs in Canada, and the impact of space design on maneuverability and use of their device in public spaces.
Aim 3: To summarize the state of knowledge considering design recommendations for children who use WhMD
Aim 4: To develop a set of recommendations for improved accessibility of the built environment for Canadians using WhMDs.

2.1. Report overview

This report is subdivided into three parts:

- Part A focuses on adult WhMD users. First, a summary of the landscape of Canadian standards and codes that relate to accessibility space and operating control installation requirements is provided. Select international standards are included for comparison. The static and functional anthropometric measurements, collected from different WhMD and other assistive device users, are then provided. Finally, we present our qualitative study exploring the lived experiences of WhMD users in Canada to better understand how design characteristics of existing environments (e.g., layout, features, spatial constraints) shape maneuverability, use, and navigation of WhMDs.
- Part B focuses on pediatric design considerations. A summary of the state of knowledge related to guidelines for pediatric space design is provided.
- Key findings, study limitations, and areas for future work are provided in Part C.

Part A: Adult mobility device users: developing a database of anthropometric and functional measurements

Part A of this project aimed to establish an updated data source to inform space requirements in accessibility codes and standards. Part A is sub-divided into several sections, including a summary of current accessibility standards and codes that relate to space requirements and operating control installation guidance, static and functional anthropometric measurements collected from different WhMD and other assistive device users, and qualitative exploration of lived experience of WhMD users.

1. Summary of existing built environment accessibility codes and standards

To contextualize the findings of the current study, a review was conducted to summarize the current landscape of accessibility standards related to spatial requirements and the installation of operating controls. Accessibility codes and standards from Canada were examined and summarized in Tables 2 to 4. Select resources from the United States, the United Kingdom, and Australia were included.

This summary allows for evaluation of how our results from our laboratory data collection and population-level estimates (3.0, Results) align with existing standards and highlights opportunities to strengthen harmonization of design guidance in Canada.

Table 2. Summary of select codes and standards across Canada (and internationally) defining accessible clear floor space and clearance requirements

	Clear floor area (width and length)	**Knee clearance (height and depth)**	**Toe clearance (height and depth)**
CSA/ASC B651: 2023 – Accessible Design for the Built Environment	820mm x 1390mm (for a stationary position)	685mm x 200mm	230mm x 230mm
CSA/ASC B652: 2023 – Accessible Dwellings	820mm x 1390mm (for a stationary position) 900mm x 1500mm (for bathroom transfer space)	685-730mm x 200mm	230mm x 230mm
CAN-ASC-2.1 – Outdoor Spaces (Draft)	900mm x 1500mm (for a stationary position) 2200mm x 900mm (for lateral approach parallel to item or object)	685mm x 280-480mm	230mm x 430mm
CAN-ASC-2.3 – Model Standard for the Built Environment (Draft)	900mm x 1500mm (for forward approach) 2200mm x 900mm (for parallel approach) 2100mm x 2100mm (for approach and transfer)	685mm x 300mm	350mm x 500mm
CAN-ASC-2.2 – Emergency Egress (Draft)	900mm x 1500mm (for a stationary position)	*Not defined in standard*	*Not defined in standard*

CAN-ASC-2.8:2025 – Accessible-Ready Housing	820mm x 1390mm (for a stationary position)	*Comply with ASC/CSA B652*	*Comply with ASC/CSA B652*
National Building Code of Canada (2025)	800mm x 1350mm (for a stationary position) 900mm x 1500mm (for bathroom transfer space)	685-735mm x 200mm	230mm x 280-430mm
ICC/ANSI A117.1:2017 – Accessible and Usable Buildings	760mm x 1320mm (for a stationary position)	685mm x 205-280mm	230mm x 430mm
2010 ADA Standards for Accessible Design	760mm x 1220mm (for a stationary position)	685mm x 205-280mm	230mm x 430mm
AS-1428.1:2021 – Design for Access and Mobility	800mm x 1300mm (for a stationary position)	720mm x 240mm	300mm x 200mm
Approved Document M (2015): Access to and Use of Buildings, Volume 2	900mm x 1400mm (for a stationary position) 1200mm x 1800mm (for forward approach to reception desk or counter) 1400mm x 2200mm (for lateral approach to reception desk or counter)	700mm x 500mm	*Not defined in standard*

Table 3. Summary of select codes and standards across Canada (and internationally) defining accessible space requirements for circulation

	Clear width, path of travel	Passing area, path of travel	Short restrictions, path of travel	Door width	Turning area	T-turns	U-turn around a barrier
CSA/ASC B651: 2023 – Accessible Design for the Built Environment	1200mm (interior)	1800mm x 1800mm (every 24m)	860mm (up to 600mm in length) 1000mm (checkout lanes)	860mm	2100mm x 2100mm (interior)	1200mm x 1800mm x 1200mm	1200mm x 1200mm x 1200mm
CSA/ASC B652: 2023 – Accessible Dwellings	1200mm (interior) 1500mm (exterior) 1000mm (home alterations)	*Not defined in standard*	860mm (up to 600mm in length)	860mm	Turning diameter: 1800mm (new); 1500mm (home alterations) 2100mm x 2100mm (short-term accommoda tions)	1200mm x 1800mm x 1200mm (new) 1000mm x 1500mm x 1000mm (home alterations)	*Not defined in standard*
CAN-ASC-2.1 – Outdoor Spaces (Draft)	2000mm (exterior)	2000mm x 2000mm (every 100m) for	1200mm (outdoor surfaces)	850mm	2100mm x 2100mm	*Not defined in standard*	900mm x 2000mm x 900mm (300mm

		outdoor surfaces 1700mm x 1700mm (every 100m) for trails	1000mm (trails)				wide obstacle)
CAN-ASC-2.3 – Model Standard for the Built Environment (Draft)	1800mm (interior) 2500mm (exterior)	*Not defined in standard*	1100mm (up to 600mm in length) 1000mm (checkout lanes)	950mm	2500mm diameter	*Not defined in standard*	*Not defined in standard*
CAN-ASC-2.2 – Emergency Egress (Draft)	*Comply with ASC/CSA B651*	*Not defined in standard*	*Not defined in standard*	*Comply with ASC/CSA B651*	2100mm radius	*Not defined in standard*	*Not defined in standard*
CAN-ASC-2.8:2025 – Accessible-Ready Housing	1200mm (interior) 1500mm (exterior)	*Not defined in standard*	860mm (up to 600mm in length)	860mm	1800mm diameter	1200mm x 1800mm x 1200mm	*Not defined in standard*
National Building Code of Canada (2025)	1000mm (interior) 1600mm (exterior)	1700mm x 1700mm (every 24m)	850mm (up to 600mm in length)	850mm	1700mm diameter 1700mm x 1500mm	1000mm x 1700mm x 1000mm	*Not defined in standard*
ICC/ANSI A117.1:2017 – Accessible and Usable Buildings	915mm (interior)	1525mm x 1525mm (every 61m)	815mm (up to 610mm in length)	815mm	1700mm diameter (new)	915mm x 915mm x 915mm	For obstacle <1320mm wide:

	1220mm (exterior)				1525mm diameter (existing)	965mm x 1065mm x 965mm 1015mm x 1015mm x 1015mm	915mm x 1525mm x 915mm 1065mm x 1220mm x 1065mm 1090mm x 1090mm x 1090mm
2010 ADA Standards for Accessible Design	915mm (interior)	1525mm x 1525mm (every 61m)	815mm (up to 610mm in length)	815mm	1525mm diameter	915mm x 1525mm x 915mm	For obstacle <1220mm wide: 1065mm x 1220mm x 1065mm
AS-1428.1:2021 – Design for Access and Mobility	1000mm (interior) 1500mm (exterior)	1800mm x 2000mm	*Not defined in standard*	850mm	2070mm x 1540mm	*Not defined in standard*	*Not defined in standard*
Approved Document M (2015): Access to and Use of Buildings, Volume 2	1200mm (interior) 1800mm (exterior)	1800mm x 1800mm	*Not defined in standard*	800mm (interior) 1000mm (exterior)	1800mm x 1800mm	*Not defined in standard*	*Not defined in standard*

Table 4. Summary of select codes and standards across Canada (and internationally) defining accessible design elements guided by reaching ranges

	General operating control installation height range (mm)*	**Max reach height (mm) over obstruction**	**Door hardware installation height range (includes power door operators)**
CSA/ASC B651: 2023 – Accessible Design for the Built Environment	400mm – 1200mm	1100mm (if forward reach, for 600mm depth using touch or 500mm depth using grasp); 1200mm (if lateral reach, for 600mm depth using touch or 500mm depth using grasp)	900mm – 1100mm
CSA/ASC B652: 2023 – Accessible Dwellings	400mm – 1100mm	1100mm (for 600mm depth using touch or 500mm depth using grasp)	900mm – 1100mm
CAN-ASC-2.1 – Outdoor Spaces (Draft)	460mm – 1100mm	1100mm (for max 500mm depth)	460mm – 1100mm
CAN-ASC-2.3 – Model Standard for the Built Environment (Draft)	400mm – 1100mm	1100mm (if forward reach) 860mm (if lateral reach)	900mm – 1100mm
CAN-ASC-2.2 – Emergency Egress (Draft)	1200mm (max)	*Not defined in standard*	*Not defined in standard*
CAN-ASC-2.8:2025 – Accessible-Ready Housing	400mm – 1100mm	*Not defined in standard*	*Comply with CSA/ASC B652*

National Building Code of Canada (2025)	400mm – 1200mm	1100mm (for depth <500mm)	900mm – 1100mm
ICC/ANSI A117.1:2017 – Accessible and Usable Buildings	380mm – 1220mm	For forward reach: 1220mm (if depth <510mm) or 1120mm (if depth >510mm and <635mm) For lateral reach: 1220mm (if depth <255mm) or 1170mm (if depth >255mm and <610mm)	865mm – 1220mm
2010 ADA Standards for Accessible Design	380mm – 1220mm	For forward reach: 1220mm (if depth <510mm) or 1120mm (if depth >510mm and <635mm) For lateral reach: 1220mm (if depth <255mm) or 1170mm (if depth >255mm and <610mm)	865mm – 1220mm
AS-1428.1:2021 – Design for Access and Mobility	900mm – 1100mm	*Not defined in standard*	900mm – 1100m (grasp & turn) 900mm – 1200mm (push in direction of travel) 900mm – 1200mm (touch only) 500mm – 1000mm (power-door operators)

Approved Document M (2015): Access to and Use of Buildings, Volume 2	400mm – 1200mm 750mm – 1200mm (for controls requiring precise hand movements)	*Not defined in standard*	750mm – 1000mm

*General operating range installation is provided in this table; modified specifications may exist for specific control types (e.g. faucets, hand-dryers, visual displays, etc)

2. Evaluation of functional space requirements and anthropometric measures

As a major component of this project, we sought to collect static and functional anthropometric from adult users of mobility assistive devices. We primarily focused on wheeled mobility device users (manual wheelchairs, power wheelchairs, scooters), but also included individuals who used walkers/rollators, or travelled with guide dogs. General methods are provided in 2.1.2 to 2.1.4, with detailed descriptions for each static measurement/functional maneuver provided alongside the collected results (3.0, Results).

2.1. Participant recruitment

Anthropometric and functional measurements were collected from individuals with disability using walkers/rollators, manual wheelchairs, power wheelchairs, mobility scooters, and/or those travelling with service animals.

Data was collected from participants across Ontario, Canada by members of the research team who were trained in the data collection protocol. This project used community convenience sampling to recruit and enrol participants. We aimed to recruit an equal number of participants for each type of mobility device/aid as well as an equal number of male and female participants. Eligible participants included: adults (18 years or over) who regularly used a mobility device/aid during everyday functional activities and were able to communicate in English.

2.1.1. Demographics and mobility device use

A questionnaire was used to collect the demographic information of each participant. Participants were asked to provide the following demographic details:

- Age
- Sex
- Gender
- Disability type
- Social Identity

Information was also collected related to each participant's use of mobility devices and/or aids. Details regarding the make and model of each mobility device used by participants during our testing were documented. Participants also reported the number and types of mobility devices they used, along with their level of experience operating each device.

2.1.2. Determining anthropometric measurements

Anthropometric measurements of each participant and their mobility device/aid were recorded under static conditions. All dimensions were measured using a tape measure and recorded in millimetres (mm) while participants were positioned in their preferred configuration, including any accessories, personal items, or equipment typically used. User weight was collected using a portable scale designed specifically for the purposes of this study and recorded in kilograms (kg). Photographs of the participant and their mobility device/aid were taken from anterior (front), sagittal (side), and overhead views to capture their set-up.

The static measurements collected for this study are described below:

- **Unoccupied device width:** horizontal distance between the most lateral points of the mobility device.
- **Unoccupied device length:** horizontal distance between the most anterior and posterior points of the mobility device.
- **Occupied device width:** horizontal distance between the most lateral points of the mobility device user for functional tasks.
- **Occupied device length:** horizontal distance between the most anterior and posterior points of the mobility device user.
- **Seat height:** vertical distance between the floor and top of the thigh in a seated position
- **Seat depth:** horizontal distance between the most anterior point of the mobility device/occupant and the midline of the hips.
- **Knee height:** vertical distance between the floor and the top of the knee
- **Knee depth:** horizontal distance between the most anterior point of the mobility device/occupant and the centre of the knee.
- **Toe height:** vertical distance between the floor and the highest point on the foot
- **Toe depth:** horizontal distance between the most anterior point of the mobility device/occupant and the midline of the ankle.
- **Eye height:** vertical distance between the floor and the midline of the eyes
- **Occupied device weight:** combined weight of the occupant seated in their mobility device.

2.1.3. Determining minimum space requirements

To better guide functional space requirements in the built environment, all participants completed a series of functional maneuvers using their own mobility device/aid. For each maneuver evaluated in this study, participants were instructed to proceed at their preferred speed and in their preferred direction of travel (i.e., clockwise or counter-clockwise).

Foam walls were used to create the boundaries that defined the testing space for each maneuver. Participants performed each maneuver within the space that was progressively being reduced by 100 mm following each successful attempt. A maneuver was considered successful if the participant completed it without contacting the walls. Testing continued until the participant was unable to complete the maneuver within the bounded space or until a pre-defined minimum dimension was reached. The smallest successfully completed dimension was recorded as the participant’s minimum space requirement for that maneuver. Given that the primary aim of this work was to inform public space design, predefined minimum dimensions were established to limit participant burden by reducing the number of maneuvers required. This approach also enabled identification of devices that required more space than is currently permitted under minimum accessibility standards (i.e., participants unable to meet existing minimums). However, a subsample of participants completed the maneuvers without a predefined minimum restriction, continuing until their absolute minimum space requirement was reached. These data are summarized in Appendix C.

The functional maneuvers collected for this study are briefly described below and illustrated in Figure 1. Details for each maneuver can be found alongside the results.

a) **Continuous and non-continuous (e.g. three-point) U-turn within a bounded space:** participants were instructed to complete both a continuous (if possible) and non-continuous (three-point) U-turn, within the defined space.
b) **Turning within a bounded space, with a fixed width, middle entry/exit**: participants were instructed to complete a turn within a bounded space (continuous or non-continuous) that includes a fixed width, middle entry/exit door.
c) **Turning within a bounded space, with a fixed width, corner entry/exit:** participants were instructed to complete a turn within a bounded space (continuous or non-continuous) that includes a fixed width, corner entry/exit door.
d) **Navigating a straight, clear path of travel:** participants were instructed to travel straight, down a short corridor.
e) **90-degree turn around a corner (L-Turn):** participants were to complete a turn around a corner.
f) **Turning around a barrier:** participants were instructed to complete a turn around a centrally located barrier (3” width), with three equidistant widths between the barrier and the outer boundary walls.

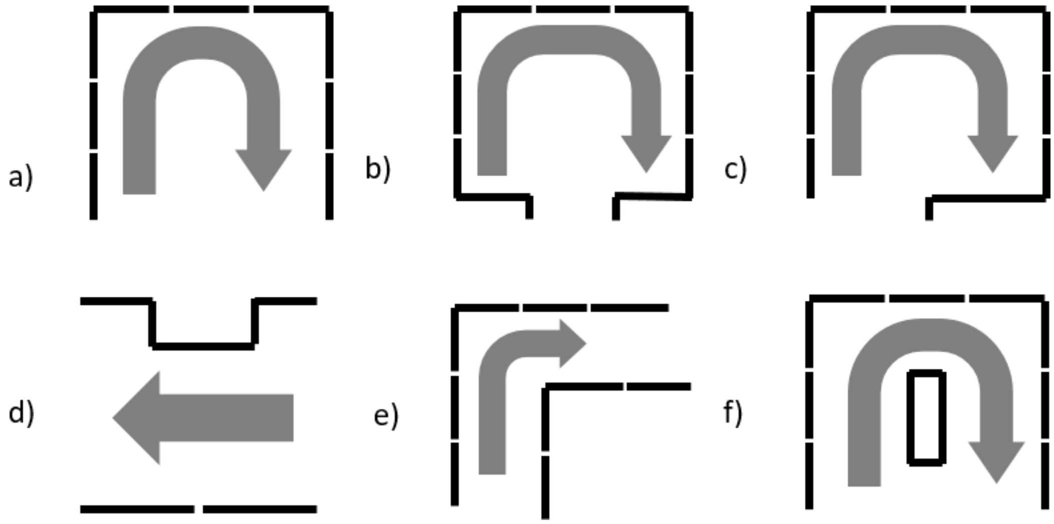

Figure 1. Illustration of the various functional maneuvers completed by participants. a) Continuous (and non-continuous) turning in a bounded area; b, c) Non-continuous U-turn, with a fixed width entry/exit door centrally located (b) or located in the corner of the space (c); d) travel down a straight path; e) 90-degree or L-turn; f) turning around a barrier

2.1.4. Determining functional reach ranges

To guide placement ranges for operating controls and devices (e.g., light switches, door handles, faucets), participants completed a series of functional reaching tasks. Where possible, reaching was assessed in forward and lateral directions, with and without an obstruction. For obstructed reaching, a foam table (height: 860 mm; width: 800 mm; depth: 500 mm and 600 mm; under surface clearance: 730mm) was positioned between the participant and the wall. Participants self-selected their preferred starting distance from the wall to complete each task; this distance was measured from the most proximal point of the participant or their mobility device/aid to the wall and recorded as "tolerance."

Once in a preferred position, participants were instructed to reach as high or low as comfortable in a safe and controlled manner, using their preferred arm. For both maximum and minimum heights, the reaching tasks included pressing a button ("Touch" task) and placing an object on a shelf ("Grasp" task). Height was measured as the vertical distance from the centre of the button or the top surface of the shelf to the floor, respectively.

2.2. Boostrapping analysis

To enhance and strengthen the generalizability of our findings to the Canadian population, a statistical bootstrapping approach was applied to generate proportionally representative samples of the Canadian population based on mobility device type (i.e., manual wheelchair, power wheelchair, and scooter). This approach was adapted from Paquet et al., (2012) using population-level distributions derived from the 2022 Canadian Survey on Disability (CSD; see 1.1). According to summary statistics using CSD 2022 data, 53.9% of wheeled mobility devices were manual wheelchairs, 32.4% were mobility scooters, and 13.8% were power wheelchairs. These proportions were compared to the distribution observed in our collected sample (37.2% manual wheelchairs, 48.2% power wheelchairs, and 14.7% scooters), revealing notable differences. Given this discrepancy, bootstrapped resampling was conducted to better align our collected participant sample with national prevalence estimates and support population-level recommendations.

Bootstrapping is one of many different resampling methods where the objective is to create multiple samples from a single dataset to infer the sampling distribution of an estimate of the data. This can allow for an estimate of a population to be produced from sample data. The bootstrap method of resampling is advantageous as it does not require an assumption of normality; however, is limited by the available sample size and relies on the assumption that the data being resampled is representative of the population it is trying to simulate (Diciccio & Romano, 1988; Chong & Choo, 2011).

To determine the number of each device that should be included in the simulated dataset, the 2022 CSD percentage for each device type was multiplied by the sample size of the original dataset. This determined the number of times each device type from the original sample should be included when creating each simulated dataset. Due to the high prevalence of walkers among the types of mobility devices used, only manual wheelchairs, power wheelchairs and mobility scooters (i.e. wheeled mobility devices) were resampled proportionally to the Canadian population; this was done to prevent the suppression of wheeled mobility devices.

MATLAB software (MATLAB R2025a) was used to complete the bootstrapping analysis, wherein the original sample was resampled to create simulated datasets of the same size as the original sample. To ensure the dataset was proportionately representative of device use among Canadians, the simulated datasets resampled more scooter and manual wheelchair users and fewer power wheelchair users. Bootstrapping with replacement was used to allow data points (i.e. devices) to be represented more than once in each simulated dataset. Each simulated dataset is created independently of each other and populated through random selection of data point from the original sample. This resampling process was repeated 4000 times to create 4000 simulated datasets as done by Paquet et al., (2012) with each dataset proportionally representing the distribution of wheeled mobility device use among Canadians with a disability.

Descriptive statistics (e.g. mean, standard deviation, and percentiles) were evaluated following the creation of each simulated dataset. The average of each descriptive statistic across the 4000 simulated datasets was evaluated to produce the final statistical values along with their corresponding confidence intervals. Descriptive statistics for the individual device subgroups were presented separately to understand their contributions to the final bootstrapped estimates.

Bootstrapping analysis was completed for the static measures, functional maneuvers and reaching ranges for the group of wheeled mobility devices (i.e. manual wheelchairs, power wheelchairs, and scooters). Modifications to the bootstrapping approach were made for *Static Measures* due to restrictions in certain devices when completing tasks. Specifically, manual wheelchairs and power wheelchairs were the only devices evaluated for some static measures (i.e. seat, knee, and toe clearances did not include mobility scooters due to steering columns). Therefore, a different percentage was used to determine the number of manual wheelchairs versus power wheelchairs that should be resampled. For all bootstrapped measures of "Wheelchairs Only", the simulated datasets were resampled to be 80% manual wheelchairs and 20% power wheelchairs to maintain a proportionally representative subsample. No modifications were required for the *Functional Maneuvers* and *Reaching Ranges.*

3. Results

3.1. Characteristics of adult mobility assistive device users

A total of 222 participants who used a mobility assistive device were included in our final sample, including: Adults using walkers/rollators (*n*=30); Adults using mobility scooters (*n* =28); Adults using manual wheelchairs (*n* =70); Adults using power wheelchairs (*n* =91); Adults using guide dogs (*n* =3). Participant demographics for each group are summarized in Table 5 below.

3.1.1. Age, sex, and gender

The mean (SD) age of all participants was 57.9 (16.8) years old. Approximately 55% of participants identified as women, with ~42% as men, and the remainder identifying as non-binary or not sharing their gender identity. Among mobility device sub-groups**,** gender distribution was similar to the overall group except walker users, which had a high proportion of participants who identified as women (80%).

3.1.2. Social identity

Participants self-reported social identity groups to which they belonged. While ~70% of the sample did not identify with the available options or preferred not to disclose that information, approximately 30% identified with at least one of the social identity options. More than 1 in 5 participants identified as being a visible minority, while nearly 1 in 10 identified as belonging to an LGBTQI2S+ identity.

3.1.3. Disability status

Participants self-reported types of disability they experienced. In addition to mobility, participants primarily experienced other physical disabilities: flexibility (63.5%), pain (57.2%), and dexterity (49.5%). Other disabilities (mental health, visual, memory, hearing, learning, developmental, other) did not exceed 30% in the total study population or in any mobility device sub-group. Nearly half of all participants reported experiencing two to three disability types, while ~45% reported experiencing four or more disabilities.

3.1.4. Experience with mobility device

Overall, 21% of participants reported having less than a year of experience with their mobility device type. Among participants with more than a year of experience, the average level of experience with the tested device type was 13.5 (12.2) years. Details pertaining to the tested WhMDs can be found in Appendix A

Table 5. Characteristics of adult mobility assistive device users

	All Device Users	All WhMDs	Manual Wheelchair	Power Wheelchair	Mobility Scooter	Walker Users	Guide Dog Users
Number of participants							
Total, N	222	189	70	91	28	30	3
Age							
Mean (SD)	57.9 (16.8)	55.4 (16.1)	53.2 (17.5)	54.2 (15.4)	64.6 (10.5)	74.4 (12.5)	57.0 (8.0)
Sex							
Male	41.9%	45.5%	54.3%	40.7%	39.3%	20.0%	33.3%
Female	56.8%	52.9%	45.7%	57.1%	57.1%	80.0%	66.7%
Prefer not to answer	0.9%	1.6%	0.0%	2.2%	3.6%	0.0%	0.0%
Gender							
Man	41.4%	45.0%	54.3%	39.6%	39.3%	20.0%	33.3%
Woman	55.0%	50.8%	44.3%	54.9%	53.6%	80.0%	66.7%
Non-binary	3.2%	3.7%	1.4%	5.5%	3.6%	0.0%	0.0.%
Prefer not to answer	0.5%	0.5%	0.0%	0.0%	3.6%	0.0%	0.0.%
Social identity							
Visible minorities	19.4%	21.2%	12.9%	27.5%	21.4%	10.0%	0.0%
LGBTQI2S+	8.1%	9.5%	7.1%	13.2%	3.6%	0.0%	0.0%
Indigenous peoples	4.1%	4.8%	4.3%	4.4%	7.1%	0.0%	0.0%
Newcomers to Canada	3.6%	4.2%	8.6%	2.2%	0.0%	0.0%	0.0%
Gender-diverse individuals	2.3%	2.6%	1.4%	4.4%	0.0%	0.0%	0.0%
People in official language minority	1.4%	1.6%	0.0%	3.3%	0.0%	0.0%	0.0%
I do not identify	64.4%	60.3%	70.0%	51.6%	64.3%	86.7%	100.0%
Prefer not to answer	4.5%	4.8%	5.7%	3.3%	7.1%	3.3%	0.0%
Other:	0.5%	0.5%	1.4%	0.0%	0.0%	0.0%	0.0%
Number of social identities							

None identified	69.4%	65.6%	77.1%	54.9%	71.4%	90.0%	100.0%
1	23.9%	26.5%	14.3%	36.3%	25.0%	10.0%	0.0%
2 or more	6.8%	7.9%	8.6%	8.8%	3.6%	0.0%	0.0%
Disability type							
Mobility	98.6%	100.0%	100.0%	100.0%	100.0%	96.7%	33.3%
Flexibility	63.5%	63.5%	52.9%	70.3%	67.9%	66.7%	33.3%
Pain	57.2%	55.6%	48.6%	58.2%	64.3%	70.0%	33.3%
Dexterity	49.5%	49.2%	28.6%	65.9%	46.4%	53.3%	33.3%
Visual	19.8%	18.5%	20.0%	20.9%	7.1%	20.0%	100.0%
Mental Health	17.6%	19.0%	18.6%	19.8%	17.9%	6.7%	33.3%
Hearing	14.4%	12.2%	14.3%	8.8%	17.9%	30.0%	0.0%
Memory	13.5%	14.3%	14.3%	15.4%	10.7%	10.0%	0.0%
Learning	11.7%	12.2%	12.9%	13.2%	7.1%	10.0%	0.0%
Developmental	6.3%	6.9%	7.1%	7.7%	3.6%	3.3%	0.0%
Other	8.1%	9.0%	11.4%	5.5%	14.3%	3.3%	0.0%
Number of disability types							
1	7.2%	7.4%	11.4%	3.3%	10.7%	0.0%	66.7%
2 to 3	47.7%	49.2%	52.9%	46.2%	50.0%	43.3%	0.0%
4 to 5	32.0%	31.2%	28.6%	35.2%	25.0%	40.0%	0.0%
6+	12.6%	12.2%	7.1%	15.4%	14.3%	13.3%	33.3%
No response	0.5%	0.5%	0.0%	0.0%	0.0%	3.3%	0.0%
Experience with mobility device							
<1 year	20.5%	22.8%	42.9%	11.0%	10.7%	6.7%	---
1-5 years	33.3%	30.2%	22.9%	36.3%	28.6%	53.3%	---
5+ years	45.2%	46.0%	31.4%	52.7%	60.7%	40.0%	---
No response	0.9%	1.1%	2.9%	0.0%	0.0%	0.0%	---

3.2. Static measurements of adult mobility assistive device users

Static measurements were recorded from 222 adult mobility assistive device users across all device user groups. Reported sample sizes varied by outcome due to measurement-specific applicability, with some device groups not contributing data to certain outcomes (e.g., knee and toe clearances do not include scooter users). For some participants using device attachments (e.g., front-powered attachments) or accompanied by a service animal or support person, static measures were repeated under configuration-specific conditions (e.g., with and without the attachment, service animal, or support person).

Static measures of interest include those associated with clear floor space (i.e. occupied length/width; occupied clear floor area), static clearances (i.e. seat, knee, and toe clearance), occupied weight, and seated eye height. Measurement procedures for each outcome are detailed in the sections below. Descriptive statistics (minimum, maximum, mean, percentiles) are presented for each of the static measures, including laboratory-derived data and via bootstrapping analysis using resampled data based on the distribution of mobility devices among the Canadian population. Primary results are presented for WhMD users (manual wheelchairs, power wheelchairs, and mobility scooters) and wheelchairs only (e.g. excluding scooter users). Comparative results for participants using other mobility aids (e.g., walkers) are reported, when applicable, but are not included in WhMD summary statistics.

3.2.1. Clear floor space for occupied devices

Occupied measurements were collected with the device configured for use, reflecting the participant's typical/preferred positioning during functional activities (e.g. seat tilted back, foot rests extended), and included any attachments or other personal belongings added to the device. Occupied measurements are separately reported for walker users, and WhMD users when accompanied by service/support animals, support person, and/or when using a white cane (i.e. WhMD+); the WhMD+ comparative data are not included in WhMD summary statistics. Unoccupied static measurements are available in Appendix B and are reported for comparative purposes.

3.2.1.1. Occupied device width

Occupied width was measured as the lateral distance between the widest points of the participant and/or their mobility device when in use, including accessories such as bags or other personal items attached to the sides or back of the device (Figure 2). For manual wheelchair users, participants who self-propelled were asked to place their hands on the push rims, whereas those using front-powered attachment placed their hands on the handlebars. Power wheelchair users were asked to place their hands on the controls (e.g. joystick), and mobility scooter users on the steering controls. These positions were intended to reflect typical independent operation of each mobility device. Descriptive statistics of occupied device width (minimum, maximum, mean, percentiles) are presented for occupied width in Table 6.

Figure 2. Front-view image of a power wheelchair. The red, dashed arrows depict an example of the occupied measurement (e.g. from widest points on the person or device, with consideration of personal items and accessories)

Table 6. Occupied device width (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	187	495	707	73	797	824	894	990
Manual Wheelchair	70	590	731	64	811	828	859	890
Power Wheelchair	89	605	713	65	794	823	928	990
Mobility Scooter	28	495	624	63	703	717	727	730
Wheelchairs Only	159	590	721	65	810	826	903	990
Walker Users	30	570	621	40	681	688	694	695

WhMD+	6	840	1040	207	1300	1300	1300	1300
Bootstrapped estimates								
All WhMDs	187	495	695	80	793	820	864	990
Manual Wheelchair	101	590	732	64	812	830	863	890
Power Wheelchair	26	605	713	65	785	818	871	990
Mobility Scooter	60	495	624	62	700	717	727	730
Wheelchairs Only	127	590	728	64	810	829	875	990

3.2.1.2. Occupied device length

Occupied length (Figure 3) was measured as the maximum anterior–posterior distance encompassing the participant and their mobility device, including any attached accessories such as bags or other personal items affixed to the back or sides of the device. Descriptive statistics of occupied device length (minimum, maximum, mean, percentiles) are presented in Table 7.

Figure 3. Side-view image of a power wheelchair. The red, dashed arrows depict an example of the occupied measurement (e.g. from front-most to rear-most point of the person or device, with consideration of personal items and accessories)

Table 7. Occupied device length (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	187	860	1189	133	1347	1425	1511	1560
Manual Wheelchair	68	860	1097	116	1212	1220	1446	1560
Power Wheelchair	91	1000	1238	99	1345	1415	1510	1510
Mobility Scooter	28	860	1254	151	1443	1457	1504	1520
Wheelchairs Only	159	860	1177	127	1325	1371	1510	1560
Walker Users	30	735	842	77	946	995	999	1000
WhMD+	5	1200	1396	119	1492	1506	1517	1520
Bootstrapped estimates								
All WhMDs	187	860	1167	146	1364	1430	1517	1560
Manual Wheelchair	101	860	1097	115	1209	1234	1432	1560
Power Wheelchair	26	1000	1237	98	1349	1393	1445	1510
Mobility Scooter	60	860	1255	148	1435	1465	1504	1520
Wheelchairs Only	127	860	1126	125	1260	1331	1483	1560

3.2.1.3. Clear floor area

A low correlation between occupied length and width has previously been reported (D'Souza, Steinfeld, Paquet, & Feathers, 2010), suggesting that larger widths do not imply larger length and vice versa. Thus, space dimensions derived from occupied length and width considered independently may fail to accommodate devices that are long and narrow or short and wide. To prevent under or overestimating the required length and widths, clear floor area was calculated (Table 8) using established methods (D'Souza, Steinfeld, Paquet, & Feathers, 2010). Occupied length and width measurements were paired to compute individual occupied clear floor areas, from which percentile distributions were derived. Maximum occupied width and length values corresponding to the 95th percentile were then identified, providing a minimum clear floor space sufficient for at least 95% of wheeled mobility device users (Table 9).

Table 8. Clear floor area (m^2)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	186	0.46	0.8	0.13	0.99	1.07	1.22	1.26
Manual Wheelchair	69	0.48	0.8	0.12	0.94	0.96	1.09	1.19
Power Wheelchair	89	0.69	0.9	0.12	1.04	1.14	1.23	1.26

Mobility Scooter	28	0.46	0.8	0.15	0.94	0.97	1.06	1.09
Wheelchairs Only	158	0.48	0.8	0.13	1.00	1.08	1.23	1.26
Bootstrapped estimates								
All WhMDs	186	0.46	0.8	0.13	0.95	1.01	1.15	1.26
Manual Wheelchair	100	0.48	0.8	0.12	0.94	0.97	1.09	1.19
Power Wheelchair	26	0.69	0.9	0.12	1.04	1.10	1.17	1.26
Mobility Scooter	60	0.46	0.8	0.15	0.95	0.99	1.06	1.09
Wheelchairs Only	126	0.48	0.8	0.12	0.96	1.01	1.16	1.26

Table 9. Maximum width and length (mm) that would be accommodated by the 95th percentile occupied area

Data Source	Max Width	Max Length
Laboratory-derived data		
All WhMDs	890	1470
Manual Wheelchair	845	1390
Power Wheelchair	830	1470
Mobility Scooter	730	1460
Wheelchairs Only	890	1470
Bootstrapped estimates		
All WhMDs	845	1470
Manual Wheelchair	845	1390
Power Wheelchair	830	1470
Mobility Scooter	730	1460
Wheelchairs Only	845	1470

3.2.2. Summary of recommendations, clear floor space

The following summarizes our recommendations for guiding space design that applies measures of clear floor width and clear floor length

- ***Prioritize occupied, functionally realistic measurements in accessibility standards*** Occupied dimensions collected with users in their preferred, functional position better reflect real-world wheeled mobility device use than unoccupied, manufacturer-reported dimensions. While mobility scooters tend to be longer with limited variability constrained by device design, manual and power wheelchairs show greater variability due to user fit, functional adaptations, and the addition of accessories or personal items (e.g., bags, backpacks). Collecting measurements in this manner captures how devices are actually used in community settings and supports the development of more flexible and inclusive spatial requirements.

- ***Comparison with current Canadian standards and codes***
  Current Canadian standards and codes specify clear floor width and length requirements ranging from 800 mm to 900 mm and 1350 mm to 1500 mm (see Table 2), respectively. Based on the collected sample, the lower bound of both the clear floor width and length range (as specified in NBCC, 2025), would accommodate approximately 90% of wheeled mobility device users. These recommended values fall below the 95th percentile observed in both our collected and resampled datasets.

- ***Minimum occupied width and length to accommodate 95% of users***
  When resampled to reflect the population distribution of wheeled mobility devices, the findings suggest that current clear floor width and length requirements in building codes (800 mm x 1350mm) are insufficient to accommodate a user in the 95^{th} percentile. To accommodate 95% of users would require increasing the minimum stationary width to 820mm and minimum stationary length to 1430 mm.

- ***Use occupied area–based dimensions to address device shape variability***
  Defining clear floor space using the 95th percentile of occupied width and length independently may not adequately accommodate devices that are long and narrow or short and wide. To better reflect real-world device configurations and increase inclusivity, it is recommended that clear floor space be defined using the maximum occupied width and length values within the 95th percentile occupied area, resulting in recommended minimum dimensions of 845 mm (width) × 1470 mm (length).

3.2.3. Clearances

Clearance measurements were collected with mobility devices configured for use, reflecting participants' typical or preferred positioning during functional activities (e.g., seat tilted back, footrests extended). For all clearance measures (seat height, seat depth, knee clearance, and toe clearance), data are not reported for users of wheeled mobility devices with steering columns (e.g., mobility scooters, front-powered attachments), as these device features would directly influence the measurements of interest.

3.2.3.1. Seat clearance

Seat height (Figure 4) was measured as the vertical distance from the midpoint of the upper thigh to the floor, while seat depth (Figure 4) was measured from the posterior hips to the most forward point of the participant or mobility device. Descriptive statistics of seat clearance and seat depth (minimum, maximum, mean, percentiles) are presented in Table 10 and 11, respectively.

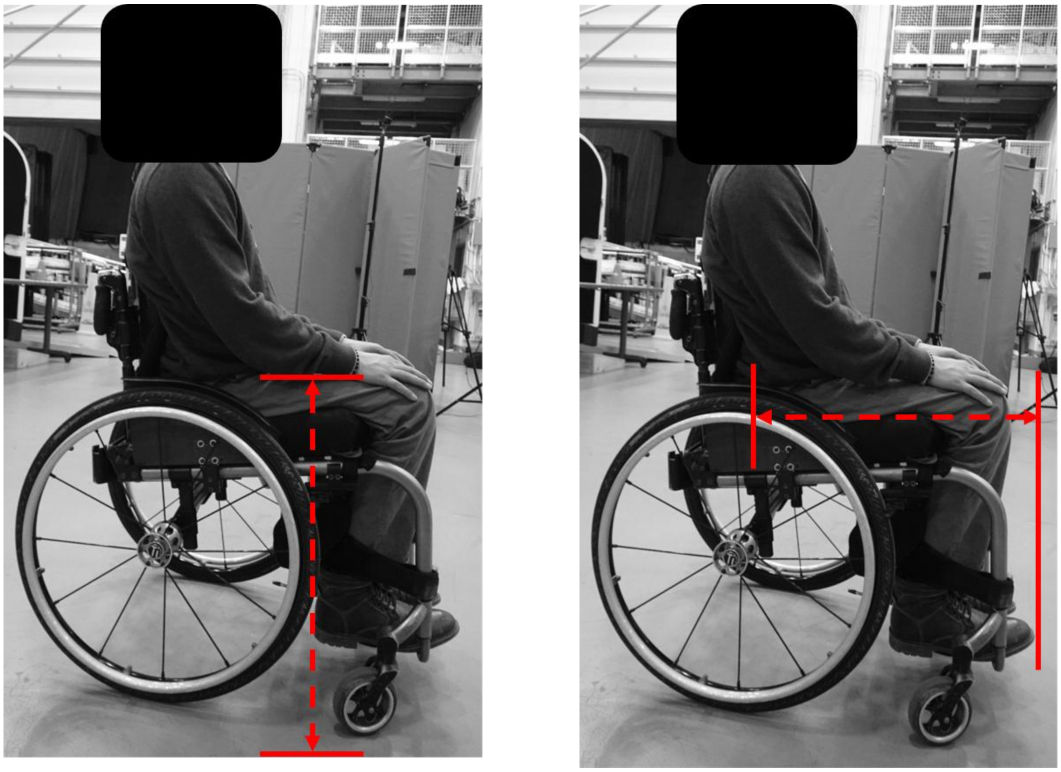

Figure 4. Side-view image of a manual wheelchair. The red, dashed arrows depict an example of seat height (left) and seat depth (right).

Table 10. Seat height (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	156	490	675	62	760	775	812	835
Manual Wheelchair	65	490	636	44	685	700	707	710
Power Wheelchair	91	575	702	58	770	798	817	835
Bootstrapped estimates								
Wheelchairs Only	156	490	649	54	708	745	787	835
Manual Wheelchair	125	490	636	44	687	700	707	710
Power Wheelchair	31	575	703	58	772	788	807	835

Table 11. Seat depth (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	156	470	712	91	828	843	932	990
Manual Wheelchair	65	470	693	95	802	838	915	960
Power Wheelchair	91	490	725	86	830	845	918	990
Bootstrapped estimates								
Wheelchairs Only	156	470	699	94	815	850	928	990
Manual Wheelchair	125	470	693	95	806	849	923	960
Power Wheelchair	31	490	725	86	825	849	893	990

3.2.3.2. Knee clearance

Knee height (Figure 5) was measured as the vertical distance from the top of the knee to the floor, while knee depth (Figure 5) was measured as the horizontal distance from the centre of the knee to the most forward point of the participant or mobility device. Descriptive statistics of knee clearance and knee depth (minimum, maximum, mean, percentiles) are presented in Table 12 and 13, respectively.

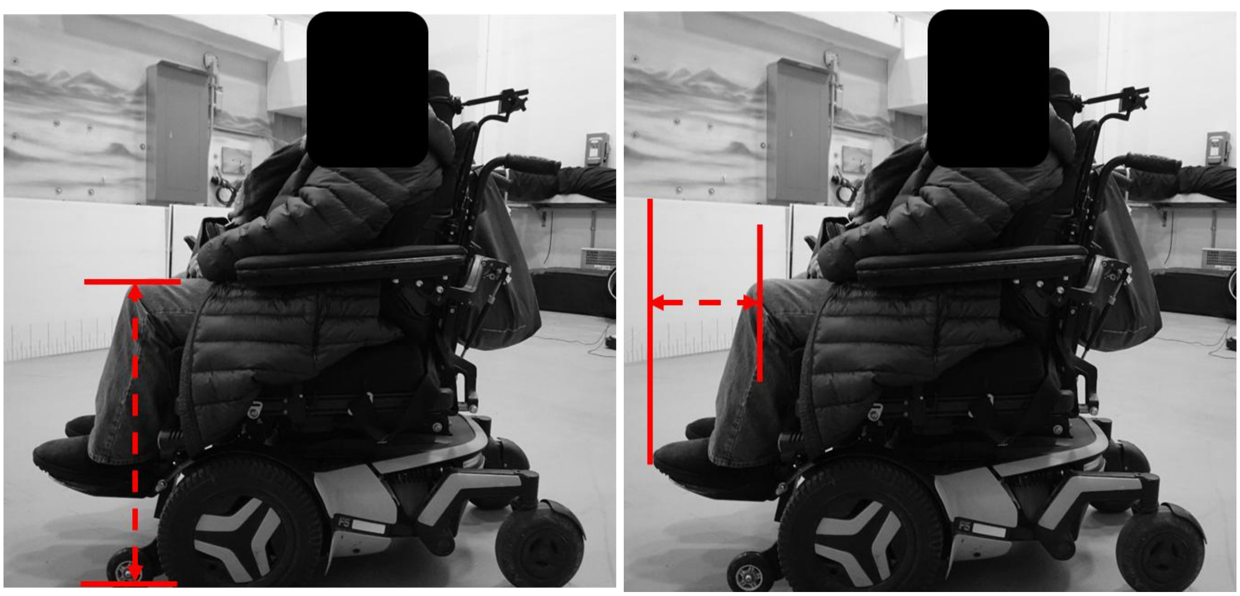

Figure 5. Side-view image of a power wheelchair. The red, dashed arrows depict an example of knee height (left) and knee depth (right).

Table 12. Knee height (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	155	510	663	65	750	778	819	855
Manual Wheelchair	64	510	629	49	680	702	716	725
Power Wheelchair	91	525	687	63	765	793	833	855
Bootstrapped estimates								
Wheelchairs Only	155	510	641	57	707	732	787	855
Manual Wheelchair	124	510	629	49	680	699	717	725
Power Wheelchair	31	525	688	63	768	787	813	855

Table 13. Knee depth (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	155	105	273	78	365	400	470	485
Manual Wheelchair	64	105	270	82	369	396	432	470
Power Wheelchair	91	110	275	76	360	395	472	485
Bootstrapped estimates								
Wheelchairs Only	155	105	271	80	368	393	450	485
Manual Wheelchair	124	105	270	81	368	392	440	470
Power Wheelchair	31	110	274	76	363	393	432	485

3.2.3.3. Toe clearance

Toe height (Figure 6) was measured as the vertical distance from the top of the foot to the floor, while toe depth (Figure 6) was measured as the distance from the centre of the ankle to the most forward point of the participant or mobility device. Descriptive statistics of toe clearance and toe depth (minimum, maximum, mean, percentiles) are presented in Table 14 and 15, respectively.

Figure 6. Side-view image of a power wheelchair. The red, dashed arrows depict an example of toe height (left) and toe depth (right).

Table 14. Toe height (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	155	50	225	84	333	395	465	595
Manual Wheelchair	64	50	182	54	259	270	277	280
Power Wheelchair	91	125	256	88	380	420	482	595
Bootstrapped estimates								
Wheelchairs Only	155	50	197	69	273	296	404	595
Manual Wheelchair	124	50	182	54	258	270	277	280
Power Wheelchair	31	125	256	87	364	406	464	595

Table 15. Toe depth (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
Wheelchairs Only	155	130	228	26	260	267	289	315

Manual Wheelchair	64	130	229	27	259	265	287	300
Power Wheelchair	91	165	227	25	260	268	284	315
Bootstrapped estimates								
Wheelchairs Only	155	130	228	26	258	268	290	315
Manual Wheelchair	124	130	229	27	258	268	289	300
Power Wheelchair	31	165	227	25	255	264	279	315

3.2.4. Summary of recommendations, seat, knee, and toe clearances

The following summarizes our recommendations for guiding space design that applies seated knee and toe clearances

- ***Applicability of seated clearance findings***
  The application of seated clearance findings for accessibility primarily apply to manual and power wheelchair users, as steering columns on devices such as mobility scooters can restrict close approach to tables, counters, sinks, and workstations. Consequently, data from users of devices with steering columns are not reported, since these features directly influence or exceed available space under tables/surfaces. For these users, it is important to also consider the clear floor space provided in front of these surfaces to ensure that a lateral approach is available for accessible use.

- ***Comparison with current Canadian standards and codes***
  Because seat clearance is not explicitly addressed in most accessibility standards, knee height clearance can be used as a practical proxy for defining the vertical space required to approach tables, counters, sinks, or workstations, etc. Current Canadian standards and codes specify minimum knee height clearances ranging from 685 mm to 735 mm (see Table 2). At the lower bound of this range, the minimum height would accommodate only 67% of all wheelchair users in the collected sample, and fewer than half of power wheelchair users. While it is possible for our power wheelchair users to potentially lower or tilt their device, depending on provided features, many individuals intentionally position their device to help with pain management. Requiring a change in one's preferred position to approach underneath desks, tables or counters for prolonged periods may cause discomfort.

  For knee clearance depths, current standards generally suggest 200 mm, with an additional 230 mm for toe clearance (see Table 2). Based on our collected data, a combined depth of 430 mm would accommodate approximately 97% of wheelchair users, supporting the retention of this combined clearance depth in design guidance.

  Finally, the minimum toe height clearance in current standards is 230 mm. This value is lower than both our laboratory-derived data and our bootstrapped estimates, accommodating only 57% of all wheelchair users, 78% of manual wheelchair users, and 43% of power wheelchair users in their preferred, functional position.

- ***Minimum seated clearances to accommodate 95% of users***
  When resampled to reflect the population distribution of wheeled mobility devices, the findings suggest the combined knee and toe depth of 430 mm, currently recommended in Canadian standards (see Table 2), is sufficient to accommodate 95% of users. However, achieving comparable accommodation for knee and toe heights would require increasing the minimum knee clearance height above 685 mm and minimum toe clearance height above 296mm.

3.2.5. Occupied device weight

Occupied device weight was determined as the total weight of the user and their mobility device, including any attached accessories such as bags or other personal items affixed to the back or sides of the device (kg). Descriptive statistics of occupied device weight (minimum, maximum, mean, percentiles) are presented in Table 16.

Table 16. Occupied device weight (kg)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	124	66	182	76	277	306	318	359
Manual Wheelchair	45	66	104	26	138	142	176	199
Power Wheelchair	61	93	244	45	307	313	335	359
Mobility Scooter	18	79	171	53	228	236	249	253
Wheelchairs Only	106	66	184	79	282	309	319	359
Walker Users	30	55	89	26	126	141	155	158
Guide Dog Users	3	98	126	36	156	162	166	167

3.2.6. Seated eye height

Seated eye height for adult mobility device users was measured with participants seated comfortably and looking straight ahead. A flat edge was positioned adjacent to the participant's face, aligned with the centre of the eye, and eye height was recorded as the vertical distance from this centreline to the floor (mm). Descriptive statistics of seated eye height (minimum, maximum, mean, percentiles) are presented in Tables 17 & 18. For comparative purposes, eye height measurements are reported separately for standing participants (e.g., walker users and guide dog users).

Table 17. Eye height range (mm)

Data Source	N	Min	Mean	SD	Max
Laboratory-derived data					
All WhMDs	189	915	1204	86	1375
Wheelchairs Only	161	915	1196	87	1375
Manual Wheelchair	70	915	1164	80	1315
Power Wheelchair	91	960	1222	85	1375
Mobility Scooter	28	1090	1245	65	1360
Walker/Guide Dog Users	33	1300	1487	89	1730
Bootstrapped estimates					
All WhMDs	188	915	1198	84	1375
Wheelchairs Only	128	915	1176	83	1375
Manual Wheelchair	102	915	1164	79	1315
Power Wheelchair	26	960	1221	84	1375
Mobility Scooter	60	1090	1245	64	1360

Table 18. Eye height percentiles (mm)

Data Source	N	1st %ile	5th %ile	10th %ile	90th %ile	95th % ile	99th %ile
Laboratory-derived data							
All WhMDs	189	958	1065	1090	1305	1345	1365
Wheelchairs Only	161	952	1065	1085	1300	1345	1365
Manual Wheelchair	70	932	1055	1065	1256	1291	1312
Power Wheelchair	91	974	1083	1130	1330	1358	1366
Mobility Scooter	28	1094	1119	1163	1313	1346	1360
Walker/Guide Dog Users	33	1311	1350	1366	1563	1626	1704
Bootstrapped estimates							
All WhMDs	188	969	1065	1088	1298	1319	1359
Wheelchairs Only	128	953	1052	1074	1281	1304	1343
Manual Wheelchair	102	951	1046	1070	1261	1287	1310
Power Wheelchair	26	1045	1092	1124	1319	1340	1356
Mobility Scooter	60	1096	1120	1157	1318	1344	1358

3.2.7. Summary of recommendations, seated eye height

- ***Comparison with current Canadian standards and codes***
  While not numerous, there is direct application in Canadian accessibility standards where seated eye heights could be considered (e.g periscope/telescope viewing heights, controls with visual displays).

- ***Minimum seated clearances to accommodate 95% of users***
  Using the 5th and 95th percentiles for all adult wheeled mobility device users to inform design elements governed by seated eye height, it is recommended that viewing features be located no lower than 1065 mm and no higher than ~1320 mm above the finished floor.

3.3. Functional maneuvers of adult mobility assistive device users

Functional measurements (e.g. maneuvers) were recorded from 222 adult mobility assistive device users across all device user groups. Reported sample sizes varied by outcome due to some participants repeating maneuvers under configuration-specific conditions (e.g., with and without front-powered attachments).

For functional maneuvers, the measures of interest include those associated with turning area (i.e. space required for a continuous turn, 3-point/non-continuous turn, and impact of entry/exit location on turning area space requirements), clear path along a corridor, L-Turn (i.e. 90-degree turn), U-turn around a barrier. Measurement procedures for each outcome are detailed in the sections below. All maneuver measures were collected with the device configured for use, reflecting the participant's typical/preferred positioning during functional activities (e.g. seat tilted back, foot rests extended), and included any attachments or other personal belongings added to the device. The minimum space was recorded for the maneuver performed in both clockwise and counter-clockwise directions, unless otherwise specified; reported values reflect the larger of the two measurements.

Descriptive statistics (minimum, maximum, mean, percentiles) are presented for each of the maneuvers, including laboratory-derived data and via bootstrapping analysis using resampled data based on the distribution of mobility devices among the Canadian population. Primary results are presented for WhMD users (manual wheelchairs, power wheelchairs, and mobility scooters). Comparative results for participants using other mobility aids (e.g., walkers, guide dogs) and WHMD users accompanied by service/support animals (i.e., WhMD+) are reported, when applicable, but are not included in WhMD summary statistics.

3.3.1. Turning area

Turning area was assessed under two conditions: continuous turning and non-continuous (3-point) turning. As described in 2.1.3, participants performed each maneuver within a square space (see Figure 7) that was progressively reduced following each successful attempt. Testing continued until the participant could no longer complete the turn without contacting the walls or until a pre-set minimum space was reached. For both continuous and 3-point turning area, the minimum allowable space was set at 1700 mm × 1700 mm, consistent with the turning space requirements outlined in the NBCC (2025).

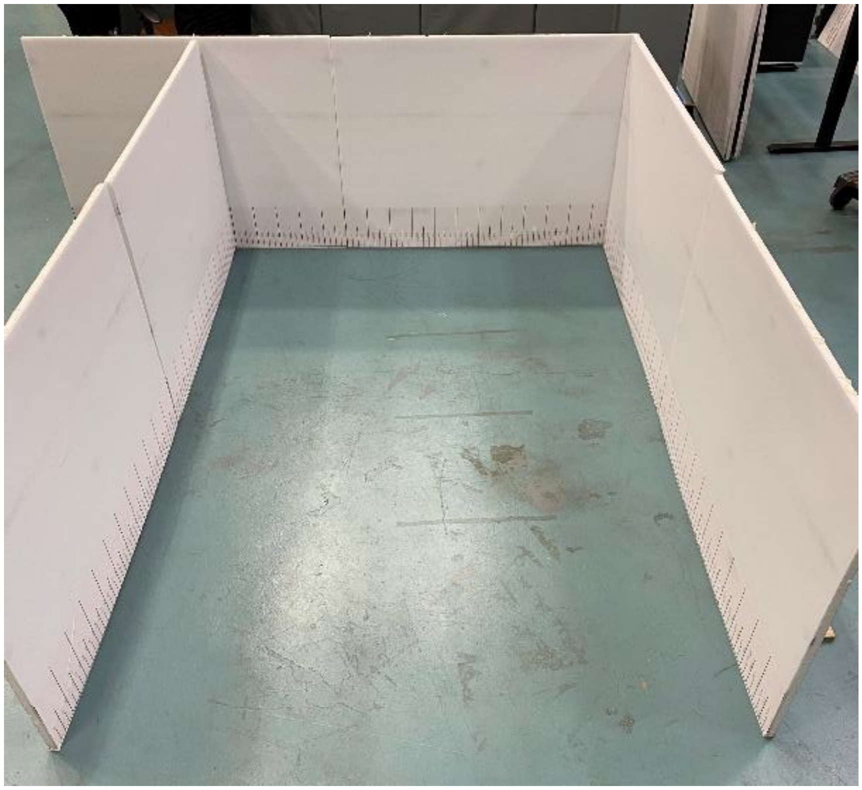

Figure 7. Image of square space bounded by foam walls, used for continuous and non-continuous turning area. The walls are movable, allowing the space to progressively reduce in size

3.3.1.1. Continuous turning area

Continuous turning area represents the minimum space required for the participant to complete a 180-degree turn in one, continuous motion, without contact with the walls. Descriptive statistics for a continuous turning area (minimum, maximum, mean, percentiles) are presented in Table 19.

Table 19. Continuous turning area (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	185	1700	1800	276	2130	2340	2948	3400
Manual Wheelchair	71	1700	1720	121	1700	1750	2140	2700
Power Wheelchair	86	1700	1707	32	1700	1700	1850	1850
Mobility Scooter	28	1700	2291	426	2900	3095	3346	3400
Wheelchairs Only	157	1700	1713	85	1700	1720	1872	2700

WhMD+	5	1700	1700	0	1700	1700	1700	1700
Walker Users	30	1700	1700	0	1700	1700	1700	1700
Guide Dog Users	3	1700	1767	116	1860	1880	1896	1900
Bootstrapped estimates								
All WhMDs	185	1700	1900	368	2363	2752	3226	3400
Manual Wheelchair	100	1700	1720	121	1703	1761	2215	2700
Power Wheelchair	26	1700	1707	32	1712	1743	1792	1850
Mobility Scooter	59	1700	2290	418	2912	3123	3335	3400
Wheelchairs Only	126	1700	1717	109	1702	1756	2166	2700

3.3.1.2. Turning area for a three-point turn

The three-point (non-continuous) turning area represents the minimum space required for a participant to complete a 180-degree turn using a non-continuous, three-point maneuver without contacting the walls. Descriptive statistics for a three-point turning area (minimum, maximum, mean, percentiles) are presented in Table 20.

Table 20. Turning area for a three-point turn (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	185	1700	1727	89	1800	1850	2124	2300
Manual Wheelchair	71	1700	1710	54	1700	1700	1960	2100
Power Wheelchair	86	1700	1707	32	1700	1700	1850	1850
Mobility Scooter	28	1700	1832	173	2100	2198	2287	2300
Wheelchairs Only	157	1700	1708	43	1700	1700	1872	2100
WhMD+	5	1700	1700	0	1700	1700	1700	1700
Walker Users	30	1700	1700	0	1700	1700	1700	1700
Guide Dog Users	3	1700	1767	116	1860	1880	1896	1900
Bootstrapped estimates								
All WhMDs	185	1700	1748	119	1859	2035	2241	2300
Manual Wheelchair	100	1700	1710	53	1700	1733	1952	2100
Power Wheelchair	26	1700	1707	32	1711	1743	1793	1850
Mobility Scooter	59	1700	1831	170	2098	2201	2278	2300
Wheelchairs Only	126	1700	1709	50	1700	1733	1945	2100

3.3.2. Impact of entry/exit location on turning area

Entry and exit with a fixed width door, in a varied location, was assessed to determine its effect on turning space requirements. A fixed-width opening (850 mm) was positioned either at the left or right corner, or at the center of the space. Participants were instructed to enter through the opening, complete the turn, and exit without contacting the walls or the opening. The available turning space was gradually reduced until the participant could no longer complete the maneuver through the space given the entry/exit location. Participants were allowed to use their preferred turning method (continuous or three-point turn). Several participants were unable to complete the task according to protocol and were excluded from summary tables. For corner entrances, reported values represent the larger of the measurements from the left- or right-corner entry/exit positions. For middle entrances, values reflect the larger measurement required to complete the turn in both clockwise and counter-clockwise directions.

3.3.2.1. Turning area, corner entry/exit

To determine the turning area required with a left- or right-sided entry/exit, openings were created at both the left and right corners of the space (see Figure 8) using a pylon and pylon cover. Participants were instructed to enter through the opening, complete a 180-degree turn, and exit through the same opening. Once their minimum turning space was identified on one side, the opening was repositioned to the opposite corner and the maneuver was repeated to confirm performance in the alternate direction. Reported values reflect the minimum turning space required to successfully complete the maneuver from both left and right corner entry/exit positions (i.e. the larger of the two minimum measurements). Descriptive statistics for a turning area with a corner entry/exit (minimum, maximum, mean, percentiles) are presented in Table 21.

Figure 8. Image of square space bounded by foam walls. A left-corner entry/exit door is shown in the image, created using a pylon. The walls are movable, allowing the space to progressively reduce in size. The door width remained fixed at 850 mm.

Table 21. Turning area with a corner entry/exit (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	175	1700	1792	223	2000	2200	2713	3200
Manual Wheelchair	67	1700	1722	114	1700	1800	2138	2600
Power Wheelchair	81	1700	1725	73	1800	1900	2020	2100
Mobility Scooter	27	1700	2167	332	2580	2735	3083	3200
Wheelchairs Only	148	1700	1724	94	1765	1850	2053	2600
WhMD+	5	1700	1720	45	1760	1780	1796	1800
Walker Users	30	1700	1700	0	1700	1700	1700	1700
Guide Dog Users	3	1700	1833	231	2020	2060	2092	2100
Bootstrapped estimates								
All WhMDs	176	1700	1864	291	2252	2488	2917	3200
Manual Wheelchair	95	1700	1722	114	1714	1801	2195	2600
Power Wheelchair	25	1700	1726	74	1783	1854	1944	2100
Mobility Scooter	56	1700	2166	326	2595	2798	3074	3200
Wheelchairs Only	120	1700	1723	107	1727	1823	2192	2600

3.3.2.2. Turning area, middle entrance

To determine the turning area required with a centrally located entry/exit, an opening was positioned at the midpoint of one wall of the space (see Figure 9) using a pylon and pylon cover. Participants were instructed to enter through the opening, complete a 180-degree turn, and exit through the same opening without contacting the walls or the opening. The maneuver was first performed in the participant’s preferred direction (e.g., clockwise). After establishing the minimum space required in that direction, the task was repeated in the opposite direction (e.g., counter-clockwise) to confirm performance. Reported values therefore represent the minimum turning space required to complete the maneuver in both directions when entering and exiting through a central opening (i.e., the larger of the two minimum measurements). Descriptive statistics for a turning area with a middle entry/exit (minimum, maximum, mean, percentiles) are presented in Table 22.

Figure 9. Image of square space bounded by foam walls. A middle entry/exit door is shown in the image, created using two pylons. The walls are movable, allowing the space to progressively reduce in size. The door width remained fixed at 850 mm.

Table 22. Turning area with a middle entry/exit (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	178	1700	1798	248	2065	2330	2823	2950
Manual Wheelchair	67	1700	1719	102	1700	1770	2104	2500
Power Wheelchair	83	1700	1717	59	1780	1845	1936	2100
Mobility Scooter	28	1700	2229	372	2800	2865	2937	2950
Wheelchairs Only	150	1700	1718	81	1700	1827	2002	2500
WhMD+	5	1700	1730	67	1790	1820	1844	1850
Walker Users	30	1700	1700	0	1700	1700	1700	1700
Guide Dog Users	3	1700	1833	231	2020	2060	2092	2100
Bootstrapped estimates								
All WhMDs	178	1700	1882	325	2378	2719	2901	2950
Manual Wheelchair	96	1700	1718	101	1705	1778	2145	2500
Power Wheelchair	25	1700	1717	58	1749	1802	1885	2100

Mobility Scooter	57	1700	2229	366	2802	2871	2930	2950
Wheelchairs Only	121	1700	1718	94	1708	1794	2130	2500

3.3.3. Summary of recommendations, turning area for public spaces

The following summarizes our recommendations for space design where a turning area would be applied.

- ***Permit three-point (non-continuous) turning where feasible***
  Allowing participants to perform a three-point turn reduces required turning space and enables accommodation of a greater proportion of users, consistent with prior literature (King, Dutta, Gorski, Holliday, & Fernie, 2011). Standards that assume only continuous turning may overestimate space requirements for some users while underestimating maneuverability strategies commonly used in practice. Designing to accommodate continuous turning requirements for scooter users may be impractical in many built environments due to the large spatial footprint required. In such contexts, permitting three-point turns may provide a more feasible approach, which better accommodate scooter users, though would still permit continuous turns for wheelchair users.

  Continuous turning space may be most relevant in specific environments, such as washrooms or housing, where individuals may prefer to avoid multi-point turns.

- ***Impact of door location on maneuverability in turning spaces***
  As shown by our data, the majority of individuals can maneuver within smaller spaces if allowed a three-point turn. However, difficulty arose when attempting to align and exit through a doorway of a smaller fixed width. In other words, restricting the entry/exit of a space increased the area required to accommodate 95% of WhMD users compared to unrestricted three-point turning. Design guidance should consider these differences when establishing maneuvering clearances for doors and vestibules, where smaller, fixed width doorways may impact maneuverability and required turning areas, with corner entrances potentially more favourable if spaces are restricted, particularly for scooter users.

- ***Comparison with current Canadian standards and codes***
  In public spaces, a provided turning area of 1700 mm × 1700 mm would accommodate approximately 82% of all WhMD users in our collected sample to perform a continuous turn. This space requirement aligns with NBCC (2025). CSA/ASC B651:23 updated requirement of 2100 mm × 2100 mm improves accommodation to approximately 90% of all WhMD users in our collected dataset performing a continuous turn. This includes nearly 100% of wheelchair users, but only 36% of scooter users. Thus, for continuous turns, current requirements are largely adequate for wheelchair users but remain insufficient for many scooter users.

If a three-point turn is considered allowable, rather than a requirement for a continuous turn, current accessibility standards of 2100 mm x 2100 mm (CSA/ASC B651:23) will accommodate the 95th percentile of our resampled dataset.

- ***Minimum turning area to accommodate 95% of users***
  For spaces without fixed-width doorways: When resampled to reflect the population distribution of wheeled mobility devices, a turning area of approximately 2750 mm × 2750 mm would be required to accommodate 95% of all WhMD users performing a continuous 180-degree turn. However, if a three-point (non-continuous) turn is permitted, a space of 2035 mm × 2035 mm is sufficient to accommodate the 95th percentile of all WhMD users. This estimate aligns closely with current accessibility standards specifying a turning area of 2100 mm × 2100 mm.

  For spaces with smaller, fixed width doorways: When spaces are restricted by a fixed-width doorway, maneuverability is impacted. When resampled to reflect the population distribution of wheeled mobility devices, the recommended turning area, where entry/exit must occur through a fixed-width doorway (~850 mm), is at least 2720 mm x 2720 mm to accommodate 95% of all WhMD users if the door is centrally located, and 2490 mm x 2490 mm if the door is located to either side of the bounded space.

3.3.4. Width of the path of travel

Participants completed a series of maneuvers to examine the impact of minimum width of the path of travel (or corridor width) on maneuverability. These tasks included forward movement along a straight path of travel, an L-turn (90-degree turn), and a U-turn around a barrier. Where available, measures related to corridor widths are separately reported for WHMD users when accompanied by service/support animals (i.e. WhMD+) and/or individuals using a Guide Dog or Walker.

3.3.4.1. Straight clear width path of travel

Participants travelled along a 2400 mm-long corridor (i.e., between two foam walls) to determine the minimum clear path of travel width (Figure 10). The lowest width tested (850 mm) aligns with several current accessibility standards (see

Table 3). Descriptive statistics for clear width path of travel (minimum, maximum, mean, percentiles) are presented in Table 23.

Figure 10. Image of straight corridor, bounded by foam walls. The walls are movable, allowing the corridor width to progressively reduce in size.

Table 23. Clear width path of travel (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	184	850	864	31	900	900	1000	1050
Manual Wheelchair	70	850	866	30	900	900	966	1000
Power Wheelchair	86	850	867	35	900	900	1008	1050
Mobility Scooter	28	850	850	0	850	850	850	850
Wheelchairs Only	156	850	866	33	900	900	1000	1050

WhMD+	5	850	1030	168	1200	1250	1290	1300
Walker Users	30	850	850	0	850	850	850	850
Guide Dog Users	3	850	900	87	970	985	997	1000
Bootstrapped estimates								
All WhMDs	184	850	861	27	900	902	965	1050
Manual Wheelchair	99	850	866	30	900	914	967	1000
Power Wheelchair	26	850	867	35	902	920	960	1050
Mobility Scooter	59	850	850	0	850	850	850	850
Wheelchairs Only	125	850	866	31	900	915	976	1050

3.3.4.2. L-turn

An L-turn represents a 90-degree change in direction within a corridor. Participants were instructed to complete both right and left 90-degree turns within our bounded space (Figure 11). The corridor width was progressively reduced until the participant could no longer complete the turn without contacting the walls, or until a predetermined minimum corridor width was reached. This minimum allowable width was set at 1000 mm, consistent with NBCC 2025. The recorded outcome reflects the minimum corridor width required to successfully complete both left and right turns, with the final reported value corresponding to the larger of the two measurements. Descriptive statistics for the corridor width required for a 90-degree or L-turn (minimum, maximum, mean, percentiles) are presented in Table 24.

Figure 11. Image of corridor with a 90-degree turn, bounded by foam walls. The walls are movable, allowing the space to progressively reduce in size.

Table 24. Corridor width to perform a 90-degree or L-Turn (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	184	1000	1019	42	1050	1100	1200	1200
Manual Wheelchair	70	1000	1014	33	1050	1050	1131	1200
Power Wheelchair	86	1000	1016	39	1050	1100	1150	1150
Mobility Scooter	28	1000	1041	64	1150	1183	1200	1200
Wheelchairs Only	156	1000	1015	36	1050	1100	1150	1200
WhMD+	5	1000	1080	130	1220	1260	1292	1300
Walker Users	30	1000	1000	0	1000	1000	1000	1000
Guide Dog Users	3	1000	1000	0	1000	1000	1000	1000
Bootstrapped estimates								
All WhMDs	184	1000	1023	47	1077	1135	1197	1200
Manual Wheelchair	99	1000	1014	33	1050	1064	1140	1200
Power Wheelchair	26	1000	1015	38	1057	1091	1123	1150
Mobility Scooter	59	1000	1041	63	1146	1181	1198	1200
Wheelchairs Only	125	1000	1014	34	1050	1074	1152	1200

3.3.4.3. U-turn around a barrier

Participants were instructed to complete a turn around a centrally positioned barrier (3”) within a bounded space (Figure 12). Three corridors were configured to equal widths, which were progressively reduced until the participant could no longer complete the maneuver successfully or until the minimum width specified by current accessibility standards was reached. The minimum set width for this maneuver was 1100 mm, aligning with the version of CSA B651 that was current at the time of data collection (CSA B651:2018).

Participants performed the turn around the barrier in both clockwise and counter-clockwise directions. The recorded outcome represents the minimum corridor width required to complete the maneuver in both directions; when different widths were required for each direction, the larger value was retained as the minimum required width. Descriptive statistics for the corridor width to perform a U-turn around a barrier (minimum, maximum, mean, percentiles) are presented in Table 25.

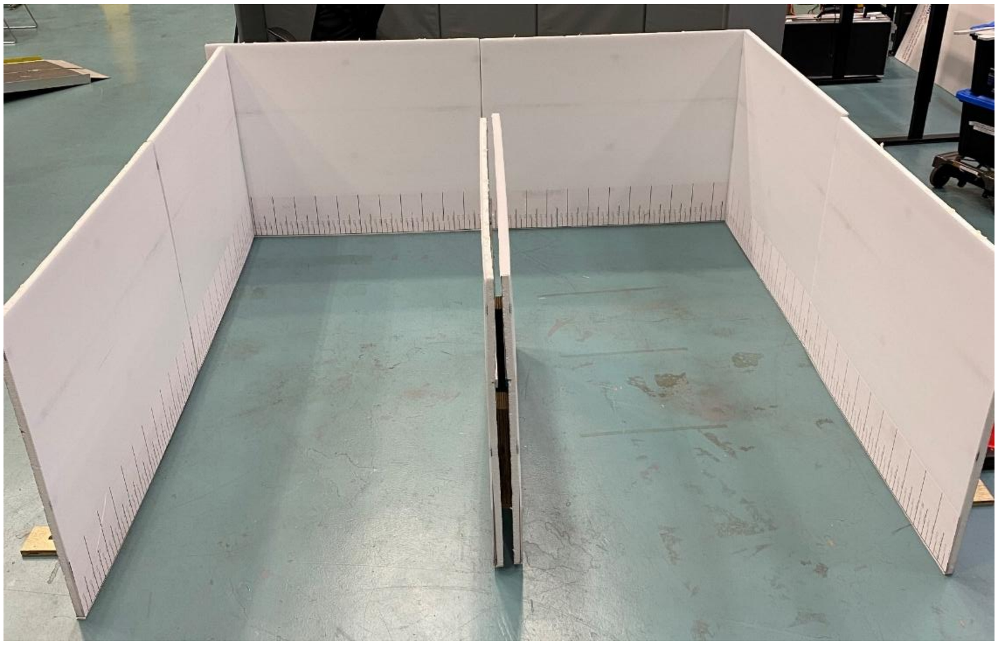

Figure 12. Image of square space bounded by three walls, with a centrally positioned barrier, bounded by foam walls. The walls are movable, allowing the space to progressively reduce in size.

Table 25. U-Turn around a barrier (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	184	1100	1115	47	1150	1200	1359	1400
Manual Wheelchair	70	1100	1103	14	1100	1100	1166	1200
Power Wheelchair	86	1100	1106	21	1125	1150	1165	1250
Mobility Scooter	28	1100	1170	98	1315	1383	1400	1400
Wheelchairs Only	156	1100	1105	19	1100	1150	1173	1250
WhMD+	5	1100	1130	45	1180	1190	1198	1200
Walker Users	30	1100	1100	0	1100	1100	1100	1100
Guide Dog Users	3	1100	1100	0	1100	1100	1100	1100
Bootstrapped estimates								
All WhMDs	184	1100	1125	64	1194	1277	1389	1400
Manual Wheelchair	99	1100	1103	14	1100	1113	1168	1200
Power Wheelchair	26	1100	1106	21	1120	1138	1165	1250
Mobility Scooter	59	1100	1170	96	1327	1376	1397	1400
Wheelchairs Only	125	1100	1104	16	1101	1125	1173	1250

3.3.5. Summary of recommendations, path of travel

The following summarizes our recommendations for space design where a width of the path of travel is used (e.g. straight path navigation, 90-degree or L-turn, U-turn around a barrier).

- ***Comparison with current Canadian standards and codes***
  In public spaces, the required clear width path of travel varies across accessibility standards. The CSA/ASC B651:23 standard specifies a minimum clear width of 1200 mm, whereas several other standards require greater widths (see Table 3). This minimum width may also apply to spaces with an L-turn (90-degree turn) or turning around an obstacle. In contrast, NBCC (2025) permits a reduced width of 1000 mm.

  For both our collected and resampled data, the clear width path of travel of 1200 mm accommodates 100% of wheeled mobility device (WhMD) users when navigating a straight line or L-turn. A reduced width of 1000 mm, as permitted by the NBCC (2025), would accommodate approximately 90^{th} percent of WhMD users performing an L-turn, and 100% of users navigating a straight path of travel, though this is without consideration of, or accounting for, a passerby.

- ***Minimum width of the path of travel to accommodate 95% of users***
  When resampled to reflect the population distribution of wheeled mobility devices, the recommended minimum width of the path of travel is 1200 mm, consistent with the current standard outlined in CSA/ASC B651:23. In our dataset, while this width accommodates 100% of wheeled mobility device users navigating a straight line, and performing the L-turn maneuver, this also closely aligns with the space requirements observed for other users, including WhMD users travelling with a service animal. This recommended width supports navigation when other users of the space, such as passersby, are taken into account. However, if a U-turn around a barrier is required, according to our resampled dataset, a minimum width of at least 1280 mm is recommended to accommodate 95% of WhMD users.

- ***Implications of clear width path of travel findings for doorway width requirements and passing widths for multiple mobility device users***
  Although navigation through doorways was not explicitly evaluated in this study, the clear width path of travel measurements provide insight that may inform accessible doorway widths. For example, the 900 mm width identified as accommodating approximately 95% of users for straight path navigation exceeds the minimum clear opening of many doorway standards (see Table 3).

  It is important to note that our clear width path of travel measurement reflected straight navigation over a brief distance, and does not reflect the short movement through doorway widths, where the same preferred tolerances for space may not necessarily apply. Translating clear width path of travel findings to doorway design therefore warrants careful consideration.

The clear width path of travel findings also have implications for situations in which two wheeled mobility device (WhMD) users must pass one another along a pathway. Current standards typically define passing widths for multiple mobility device users as 1800 mm or greater (Table 3). Our findings indicate that a minimum path of travel width of 1800 mm would accommodate approximately 95% of WhMD users passing one another.

3.4. Functional reaching ranges of adult mobility assistive device users

A total of 218 participants completed some or all functional reaching tasks. Participants were instructed to reach toward their maximum and minimum heights, but emphasis was placed on ensuring participants could perform a “comfortable” reach for each task (e.g. not lifting off seat, no excessive bending). All reaching tasks were collected with the device configured for use, reflecting the participant’s typical/preferred positioning during functional activities (e.g. seat tilted back, foot rests extended). Participants using power wheelchairs with elevating features were instructed to avoid raising the height of their device to accomplish the task. Each participant completed as many reaching conditions as possible using their preferred hand, though completion rates differed by task (Figure 13). Additionally, several manual wheelchair users completed the reaching tasks with and without their front-powered attachments. For these reasons, sample sizes vary across measurement outcomes.

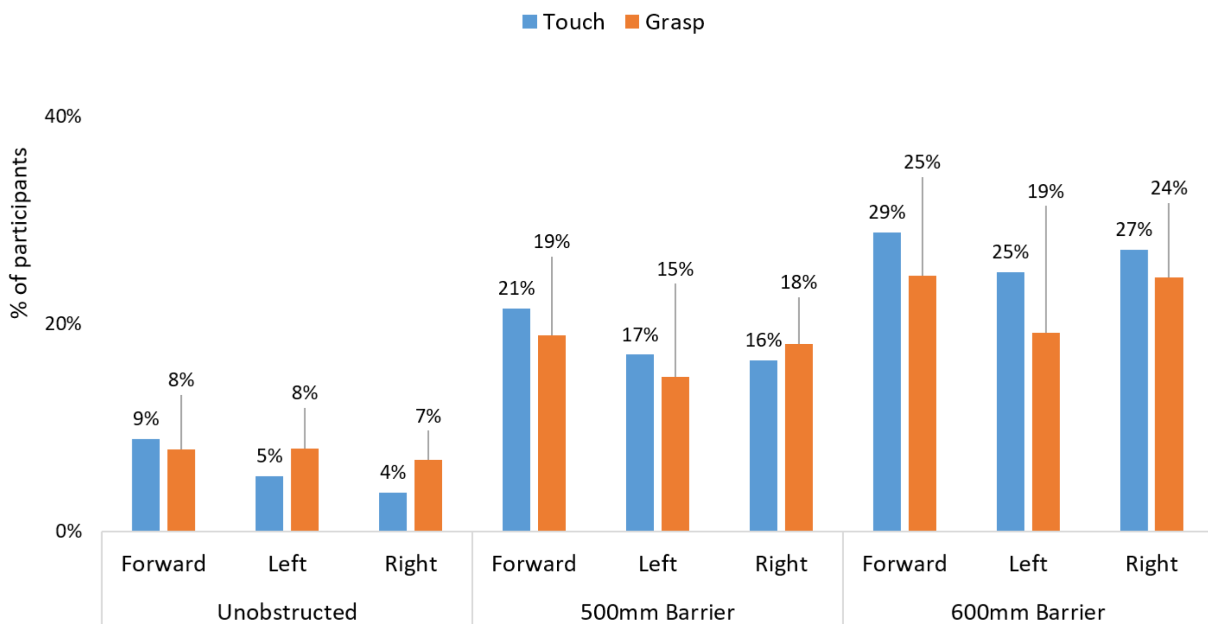

Figure 13. Percentage of our total participant sample who were unable to complete the various reaching tasks (unobstructed reaching, left; 500 mm depth obstructed reaching, middle; 600 mm depth obstructed reaching, right). Data are summarized for All WhMD users, completing the touch (blue bars) and grasp (orange bars) tasks

Descriptive statistics (minimum, maximum, mean, percentiles) are presented for each of the reaching task, including laboratory-derived data and via bootstrapping analysis using resampled data based on the distribution of mobility devices among the Canadian population. For reach ranges, bootstrapped estimates are presented for completeness but are not used to inform recommendations. Instead, recommendations are based on laboratory-derived data due to the functional demands of reaching tasks. This approach was taken, as our laboratory collected data included a higher proportion of power wheelchair users relative to population prevalence. Grounding recommendations in the collected laboratory data is therefore more functionally relevant and supports greater accommodation for wheeled mobility device users, particularly those using power wheelchairs. This is also consistent with our conservative approach used for static measurements and functional maneuvers, where we prioritize inclusivity in generating recommendations. In this case, relying on bootstrapped estimates would underrepresent power wheelchair users and potentially exclude their functional needs. Accordingly, we apply a consistent decision-making framework, using bootstrapped or non-bootstrapped data as appropriate, to ensure recommendations are both conservative and inclusive.

Primary results are presented for WhMD users (manual wheelchairs, power wheelchairs, and mobility scooters). Comparative results for participants using other mobility aids (e.g., walkers) are reported, when applicable, but are not included in WhMD summary statistics.

3.4.1. Unobstructed Reaches

Unobstructed reaches (Figure 14) were performed with participants facing the wall directly (forward) and, where possible, in parallel to the wall (left- and right-side facing). Direction is defined relative to the participant (e.g., left lateral reach = participant's left side facing the board), not the reaching hand.

Participants reached using their preferred hand to either press a 3-inch diameter button ("touch" task) or place a 0.6 kg weighted cup on a 4" deep shelf ("grasp" task). For consistency, participants were encouraged to use the same hand across successive conditions when feasible (e.g., right hand for all forward reaches). Reaching height was recorded in millimeters (mm) from the floor to the center of the button (touch task) or to the shelf height (grasp task; maximum reach height only). All reaches were performed at a self-selected distance from the wall. The distance from the wall to the nearest point of the individual, or their mobility device, was recorded as a measure of tolerance (Appendix E).

Maximum reaching heights are reported at the 1st, 5th, and 10th percentiles, representing thresholds that 99%, 95%, and 90% of participants can exceed, respectively. Minimum reaching heights are reported at the 90th, 95th, and 99th percentiles, indicating the proportion of participants able to reach below each value. Descriptive statistics for maximum and minimum unobstructed reaching heights, are presented separately for touch and grasp, and for forward vs. lateral reaching, tasks (Tables 26-31). Reach ranges across all mobility device types are summarized in Figure 15.

Figure 14. Image of a manual wheelchair user performing an unobstructed lateral touch reach (left) and an unobstructed forward grasp reach (right).

Table 26. Unobstructed forward reaching heights for a touch task (mm)

Data Source		Maximum reaching height (mm)							Minimum reaching height (mm)						
	N	**Min**	**Mean**	**SD**	**10th %ile**	**5th %ile**	**1st %ile**	**Max**	**Min**	**Mean**	**SD**	**90th %ile**	**95th %ile**	**99th %ile**	**Max**
Laboratory-derived data															
All WhMDs	174	820	1382	200	1102	1047	919	1820	30	489	226	789	860	968	1000
Manual Wheelchair	71	1090	1446	180	1190	1130	1097	1820	30	376	199	655	725	909	930
Power Wheelchair	76	820	1335	219	1033	958	891	1765	80	537	206	788	830	889	960
Mobility Scooter	27	1050	1349	146	1170	1139	1070	1595	150	652	206	860	951	997	1000
Wheelchairs Only	147	820	1388	208	1096	1030	917	1820	30	459	218	762	807	916	960
Walker Users	30	1150	1694	208	1439	1408	1220	1980	270	640	222	934	987	1000	1000
Bootstrapped estimates															
All WhMDs	174	820	1399	181	1163	1103	1004	1820	30	487	236	809	866	982	1000
Manual Wheelchair	94	1090	1445	179	1200	1139	1099	1820	30	376	198	652	733	876	930
Power Wheelchair	24	820	1335	218	1049	991	932	1765	80	537	204	778	814	859	960
Mobility Scooter	56	1050	1349	143	1168	1127	1072	1595	150	653	202	877	948	991	1000
Wheelchairs Only	118	820	1423	193	1162	1100	987	1820	30	409	209	704	779	896	960

Table 27. Unobstructed lateral reaching heights for a touch task when reaching to the left side (mm)

Data Source		Maximum reaching height (mm)							Minimum reaching height (mm)						
	N	**Min**	**Mean**	**SD**	**10th %ile**	**5th %ile**	**1st %ile**	**Max**	**Min**	**Mean**	**SD**	**90th %ile**	**95th %ile**	**99th %ile**	**Max**
Laboratory-derived data															
All WhMDs	178	780	1493	233	1155	1077	841	1940	0	408	220	712	801	917	980
Manual Wheelchair	69	900	1536	212	1246	1142	1009	1940	0	293	189	526	660	796	830
Power Wheelchair	81	780	1423	254	1105	980	804	1895	80	502	210	770	820	948	980
Mobility Scooter	28	1130	1588	159	1407	1387	1198	1830	100	416	194	710	713	777	800
Wheelchairs Only	150	780	1475	241	1148	1060	830	1940	0	406	225	721	808	925	980
Walker Users	30	1130	1659	265	1305	1262	1159	2100	260	575	236	877	907	984	1010
Bootstrapped estimates															
All WhMDs	178	780	1537	208	1243	1135	958	1940	0	362	207	679	737	833	980
Manual Wheelchair	96	900	1537	210	1239	1140	997	1940	0	293	188	539	652	785	830
Power Wheelchair	25	780	1423	252	1112	1017	914	1895	80	503	208	754	816	883	980
Mobility Scooter	57	1130	1587	156	1408	1342	1199	1830	100	417	191	701	728	776	800
Wheelchairs Only	121	780	1513	224	928	1098	928	1940	0	336	210	627	733	846	980

Table 28. Unobstructed lateral reaching heights for a touch task when reaching to the right side (mm)

Data Source		Maximum reaching height (mm)							Minimum reaching height (mm)						
	N	**Min**	**Mean**	**SD**	**10th %ile**	**5th %ile**	**1st %ile**	**Max**	**Min**	**Mean**	**SD**	**90th %ile**	**95th %ile**	**99th %ile**	**Max**
Laboratory-derived data															
All WhMDs	181	825	1478	248	1080	1015	888	1970	0	413	216	720	790	882	895
Manual Wheelchair	69	880	1548	214	1290	1172	975	1970	0	295	195	572	622	833	840
Power Wheelchair	84	825	1394	264	1017	963	879	1910	80	505	191	771	810	882	890
Mobility Scooter	28	1020	1556	199	1237	1198	1063	1830	95	429	206	710	723	850	895
Wheelchairs Only	153	825	1464	254	1068	1010	885	1970	0	410	219	720	798	864	890
Walker Users	30	1110	1702	278	1339	1226	1119	2140	270	612	236	879	985	1017	1020
Bootstrapped estimates															
All WhMDs	181	825	1530	221	1221	1078	944	1970	0	367	213	669	748	866	895
Manual Wheelchair	98	880	1548	212	1284	1161	976	1970	0	294	194	567	655	808	840
Power Wheelchair	25	825	1396	262	1045	988	929	1910	80	506	190	745	790	834	890
Mobility Scooter	58	1020	1556	195	1261	1175	1066	1830	95	430	202	701	753	850	895
Wheelchairs Only	123	825	1517	232	1199	1060	925	1970	0	337	211	627	739	836	890

Table 29. Unobstructed forward reaching maximum heights for a grasp task (mm)

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	176	735	1314	202	1060	945	875	1740
Manual Wheelchair	71	930	1369	184	1110	1055	993	1730
Power Wheelchair	78	735	1268	227	945	929	831	1740
Mobility Scooter	27	960	1305	129	1193	1187	1019	1615
Wheelchairs Only	149	735	1316	213	1048	942	870	1740
Walker Users	30	1100	1541	224	1252	1175	1120	1970
Bootstrapped estimates								
All WhMDs	176	735	1334	178	1111	1029	928	1740
Manual Wheelchair	95	930	1369	182	1111	1055	989	1730
Power Wheelchair	25	735	1268	225	990	937	875	1740
Mobility Scooter	56	960	1305	127	1190	1141	993	1615
Wheelchairs Only	120	735	1348	196	1080	1017	831	1740

Table 30. Unobstructed lateral reaching maximum heights for a grasp task when reaching to the left side (mm)

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	173	835	1355	234	1012	936	857	1800
Manual Wheelchair	69	835	1412	223	1110	1008	852	1785
Power Wheelchair	76	850	1283	244	960	890	861	1765
Mobility Scooter	28	1010	1412	182	1188	1125	1034	1800
Wheelchairs Only	145	835	1345	242	990	898	854	1785
Walker Users	30	1035	1477	245	1177	1150	1068	2040
Bootstrapped estimates								
All WhMDs	172	835	1394	217	1095	995	867	1800
Manual Wheelchair	93	835	1412	222	1104	992	867	1785
Power Wheelchair	24	850	1282	242	980	933	894	1765
Mobility Scooter	55	1010	1412	178	1184	1114	1040	1800
Wheelchairs Only	117	835	1385	232	1057	948	858	1785

Table 31. Unobstructed lateral reaching maximum heights for a grasp task when reaching to the right side (mm)

Data Source	N	Min	Mean	SD	10^{th} %ile	5^{th} %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	175	700	1355	244	1014	927	817	1835
Manual Wheelchair	69	830	1415	228	1058	986	891	1835
Power Wheelchair	78	700	1289	260	947	864	762	1835
Mobility Scooter	28	960	1394	191	1147	1082	984	1765
Wheelchairs Only	147	700	1348	253	982	892	803	1835
Walker Users	30	970	1503	252	1196	1130	1011	2070
Bootstrapped estimates								
All WhMDs	176	700	1390	224	1069	975	860	1835
Manual Wheelchair	95	830	1414	227	1077	984	888	1835
Power Wheelchair	25	700	1289	260	970	899	826	1835
Mobility Scooter	56	960	1395	187	1154	1072	990	1765
Wheelchairs Only	120	700	1388	239	1040	950	843	1835

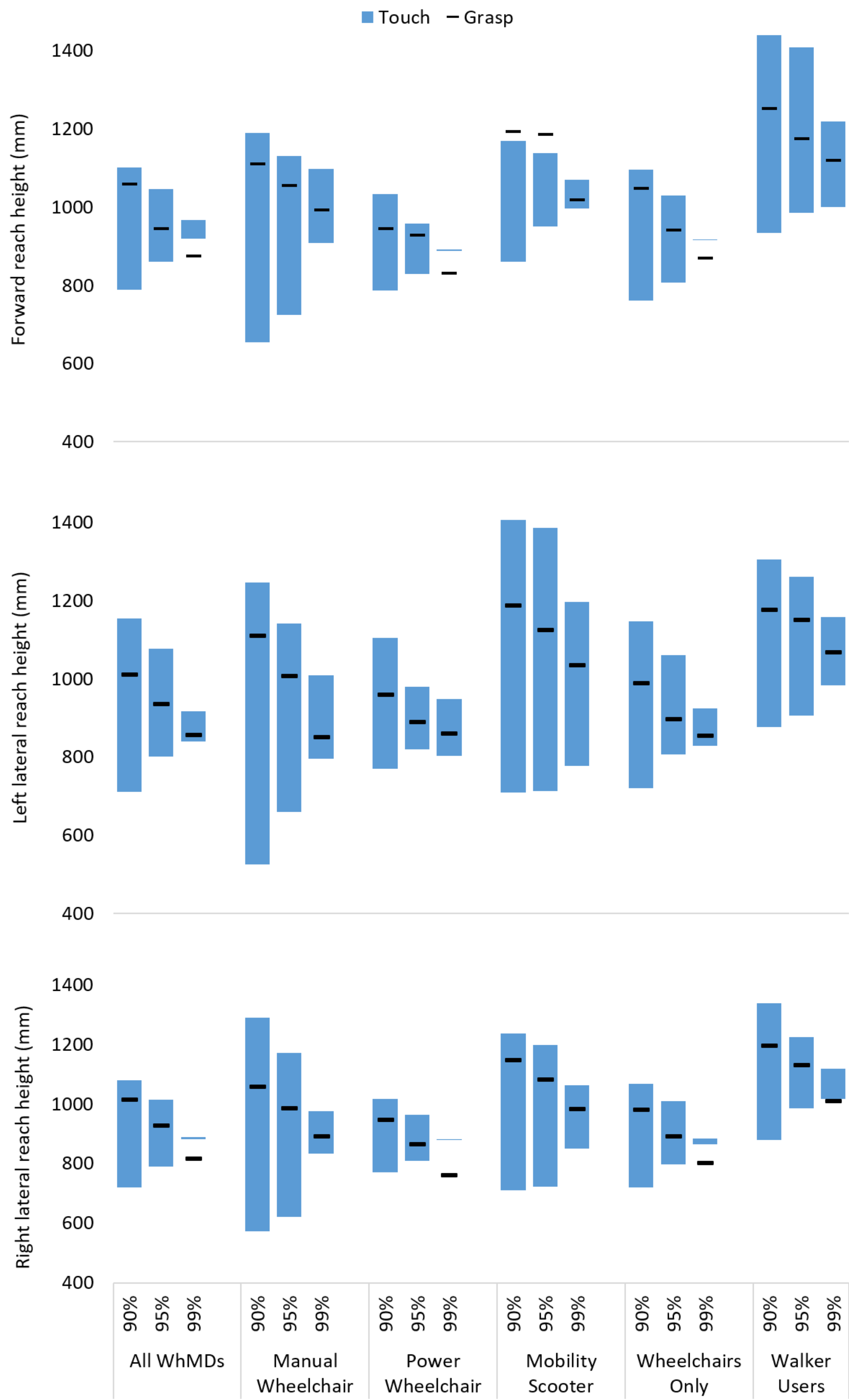

Figure 15. Unobstructed reaching ranges of mobility device users (mm), for reaching in the following directions: forward (top), lateral reaching to the left (middle), and lateral reaching to the right (bottom). Data are presented for the reaching ranges associated with the touch task (blue bars) that accommodate 90%, 95%, and 99% of participants; all WhMD users are presented as a summary, with each device type also presented individually. The maximum reaching height for the grasp task (black line) is included for comparison.

3.4.2. Summary of Recommendations, Unobstructed Reach Ranges

The following summarizes our recommendations for space design where unobstructed reach ranges be applied.

- ***Considerations of forward vs. lateral reaching, and clear floor area for unobstructed reaches***
  Forward reaches were often performed with participants' toes contacting the wall surface indicating that participants preferred to minimize their distance to achieve optimal reach height. This suggests that any obstruction within the clear floor space can meaningfully reduce effective forward reach capacity. In contrast, lateral reaches showed slightly higher sample size (e.g. greater proportion of participants able to complete lateral reaching vs. forward reaching) and greater tolerances with respect to the wall. These findings suggest that permitting a parallel approach may enhance accessibility for some users, provided that the clear floor space is designed to consider the preferred clearance from the wall (see Appendix E).

- ***Functional reach ranges for operating controls based on touching vs. grasping tasks***
  Observationally, the participants reach performance differed only slightly between touching and grasping tasks, with maximum grasp heights generally lower than maximum touch heights, reflecting the additional strength, coordination, and postural control required to functionally place or manipulate an object rather than simply make contact. These reduced grasp capacities should be carefully considered when establishing installation heights for controls or fixtures that require grasping or other tasks involving higher levels of strength, coordination, or motor control.

- ***Comparison with current Canadian standards and codes***
  The reach range envelope specified in current standards generally provides a minimum height of 400 mm from the floor and a maximum height of approximately 1100–1200 mm (see Table 4. Summary of select codes and standards across Canada (and internationally) defining accessible design elements guided by reaching ranges). These ranges are intended to guide the placement of operating controls and other accessibility features, though specific elements, such as faucets, door hardware, or visual display controls, may impose more restrictive height requirements and require a smaller installation range than the general guiding recommendations. Based on our collected sample, using a minimum height of 400 mm would accommodate fewer than 50% of participants for forward or lateral touch tasks. In contrast, a maximum height of 1100 mm, consistent with several current standards, would accommodate approximately 90% of participants for touch tasks in either direction, but fewer than 90% for grasp tasks.

- ***Reaching range to accommodate 95% of users***
  As a conservative approach, we are basing our reach range recommendations on laboratory-collected data rather than on bootstrapped estimates. In practice, it may be

difficult to anticipate whether a user will adopt a forward or lateral approach. Accordingly, our general recommendations are intended to accommodate both directions. To accommodate 95% of WhMD users in our collected sample, we recommend a maximum height of approximately 1015 mm and a minimum height of 860 mm, supporting both forward and lateral approaches for touch tasks.

Note: these recommendations are primarily based on touch activities, such as operating push buttons. Maximum grasp heights are slightly lower than touch heights, reflecting the additional strength and control required to lift or place objects, particularly at upper reach limits. Consequently, while the touch-based reach ranges can serve as the primary guide for design, the grasp task values should be used to define the upper limits of operable controls or storage areas where more demanding grasping tasks are expected, ensuring functional usability for the majority of WhMD users.

3.4.3. Obstructed reaches

Obstructed reaches (Figure 16) were assessed to determine the maximum heights participants could achieve when reaching above a fixed height counter or table surface for touch or grasp tasks. Participants completed reaching tasks over a table with a width of 800 mm, surface height of 860 mm above the floor, and an under-table clearance of 730 mm along the full depth. Two counter/table depths, 500 mm and 600 mm, were evaluated for all reaching conditions. Results were generally similar across the two evaluated depths although a greater number of participants were unable to complete the task at the 600 mm depth (see Figure 13 above), therefore we present here only the findings from the 500 mm depth condition. Results for the 600 mm depth obstruction are provided in Appendix F.

All obstructed reaches were performed at a self-selected distance from the counter/table edge. Similar to unobstructed reaching (3.4.1), maximum reaching heights are reported at the 1st, 5th, and 10th percentiles, representing thresholds that 99%, 95%, and 90% of participants can exceed, respectively. Descriptive statistics for maximum obstructed reaching heights, are presented separately for touch and grasp, and for forward vs. lateral reaching, tasks (Tables 32-37). For our obstructed reaching, several participants were unable to complete the task, reflected by the varying participant sample size presented in the summary tables. Obstructed reach ranges across all mobility device types are presented in Figure 17.

Figure 16. Image of a manual wheelchair user performing an obstructed lateral touch reach (left) and an obstructed forward grasp reach (right).

Table 32. Maximum forward reaching heights over a 500 mm depth obstruction, for a touch task (mm)

Data Source	N	Min	Mean	SD	10th %ile	5^{th} %ile	1^{st} %ile	Max
Laboratory-derived data								
All WhMDs	146	860	1326	199	1058	983	944	1760
Manual Wheelchair	66	935	1387	190	1148	1063	977	1760
Power Wheelchair	68	860	1285	201	1008	972	924	1755
Mobility Scooter	12	970	1219	127	1071	1022	980	1420
Wheelchairs Only	134	860	1335	202	1057	987	942	1760
Walker Users	29	1000	1508	235	1228	1161	1038	2020
Bootstrapped estimates								
All WhMDs	146	860	1319	189	1077	1012	955	1760
Manual Wheelchair	79	935	1387	190	1137	1070	987	1760
Power Wheelchair	20	860	1286	200	1045	1001	959	1755

Mobility Scooter	47	970	1218	122	1049	999	974	1420
Wheelchairs Only	99	860	1367	196	1105	1037	957	1760

Table 33. Maximum lateral reaching maximum heights when reaching to the left over a 500 mm depth obstruction (mm), for a touch task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	152	945	1281	184	1060	986	953	1780
Manual Wheelchair	63	980	1321	185	1064	1032	980	1780
Power Wheelchair	64	945	1238	179	1030	976	945	1565
Mobility Scooter	25	1050	1321	171	1108	1092	1060	1705
Wheelchairs Only	127	945	1279	186	1050	980	949	1780
Walker Users	28	1140	1548	248	1178	1144	1140	2000
Bootstrapped estimates								
All WhMDs	152	945	1310	180	1075	1035	977	1780
Manual Wheelchair	82	980	1321	184	1075	1025	985	1780
Power Wheelchair	21	945	1237	178	1034	1002	975	1565
Mobility Scooter	49	1050	1321	168	1108	1086	1061	1705
Wheelchairs Only	103	945	1304	186	1060	1010	973	1780

Table 34. Maximum lateral reaching maximum heights when reaching to the right over a 500 mm depth obstruction (mm), for a touch task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	152	860	1280	197	1016	973	913	1745
Manual Wheelchair	64	960	1322	191	1053	1032	963	1745
Power Wheelchair	61	860	1228	206	980	930	887	1715
Mobility Scooter	27	1000	1295	170	1087	1025	1003	1690
Wheelchairs Only	125	860	1276	203	1012	961	909	1745
Walker Users	29	1040	1544	239	1219	1114	1057	2010
Bootstrapped estimates								
All WhMDs	152	860	1301	187	1050	1006	948	1745
Manual Wheelchair	82	960	1322	189	1067	1028	977	1745
Power Wheelchair	21	860	1228	206	987	952	920	1715
Mobility Scooter	49	1000	1295	167	1086	1034	1007	1690
Wheelchairs Only	103	860	1303	196	1044	996	939	1745

Table 35. Maximum forward reaching heights over a 500 mm depth obstruction, for a grasp task (mm)

Data Source	N	Min	Mean	SD	10^{th} %ile	5^{th} %ile	1^{st} %ile	Max
Laboratory-derived data								
All WhMDs	151	905	1306	195	1060	998	948	1775
Manual Wheelchair	66	970	1362	181	1138	1063	996	1775
Power Wheelchair	71	905	1266	203	1000	960	930	1710
Mobility Scooter	14	1075	1249	153	1088	1078	1076	1570
Wheelchairs Only	137	905	1312	198	1050	990	945	1775
Walker Users	30	940	1440	241	1149	1124	989	2000
Bootstrapped estimates								
All WhMDs	151	905	1313	182	1086	1054	977	1775
Manual Wheelchair	82	970	1362	179	1139	1069	1002	1775
Power Wheelchair	21	905	1266	202	1027	991	959	1710
Mobility Scooter	48	1075	1249	148	1086	1078	1075	1570
Wheelchairs Only	103	905	1343	188	1095	1032	969	1775

Table 36. Maximum lateral reaching maximum heights when reaching to the left over a 500 mm depth obstruction (mm), for a grasp task

Data Source	N	Min	Mean	SD	10^{th} %ile	5^{th} %ile	1^{st} %ile	Max
Laboratory-derived data								
All WhMDs	156	860	1280	189	1028	990	938	1740
Manual Wheelchair	65	860	1303	198	1028	983	911	1740
Power Wheelchair	65	935	1251	192	1027	992	961	1635
Mobility Scooter	26	990	1292	151	1120	1041	996	1630
Wheelchairs Only	130	860	1277	196	1025	985	936	1740
Walker Users	27	1100	1489	249	1126	1106	1100	2010
Bootstrapped estimates								
All WhMDs	156	860	1292	182	1039	996	932	1740
Manual Wheelchair	84	860	1303	196	1037	987	915	1740
Power Wheelchair	22	935	1252	191	1031	1007	982	1635
Mobility Scooter	50	990	1292	148	1105	1046	1002	1630
Wheelchairs Only	106	860	1292	196	1028	987	919	1740

Table 37. Maximum lateral reaching maximum heights when reaching to the right over a 500 mm depth obstruction (mm), for a grasp task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	149	900	1286	192	1024	984	919	1750
Manual Wheelchair	64	950	1321	183	1080	1020	982	1750
Power Wheelchair	59	900	1246	210	988	967	903	1735
Mobility Scooter	26	965	1292	158	1100	1060	986	1680
Wheelchairs Only	123	900	1285	199	1020	981	912	1750
Walker Users	30	1000	1489	260	1120	1025	1006	2100
Bootstrapped estimates								
All WhMDs	149	900	1301	180	1064	1009	954	1750
Manual Wheelchair	80	950	1321	181	1079	1030	983	1750
Power Wheelchair	21	900	1247	208	1003	972	943	1735
Mobility Scooter	48	965	1292	156	1099	1047	992	1680
Wheelchairs Only	101	900	1305	190	1050	1006	952	1750

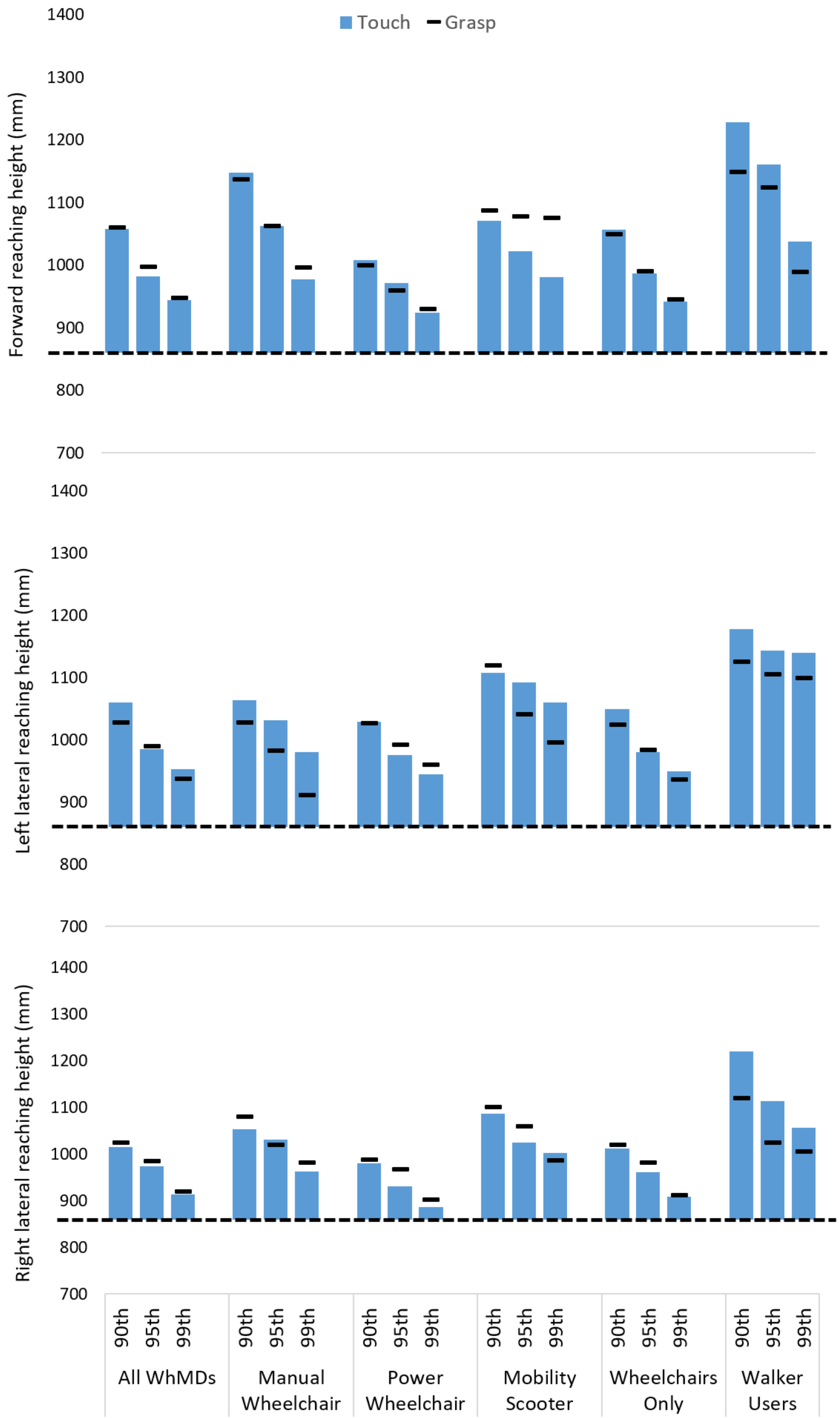

Figure 17. Obstructed reaching ranges of mobility device users (mm), across a 500 mm depth barrier, for reaching in the following directions: forward (top), lateral reaching to the left (middle), and lateral reaching to the right (bottom). Data are presented for the reaching ranges associated with the touch task (blue bars) that accommodate 90%, 95%, and 99% of participants; all WhMD users are presented as a summary, with each device type also presented individually. The maximum reaching height for the grasp task (black line) is included for comparison. Horizontal dashed line represents table height (860mm).

3.4.4. Summary of Recommendations, Obstructed Reach Ranges

The following summarizes our recommendations for space design where reach ranges over an obstruction are applied.

- ***Consideration of the depth of the obstruction***
  For this study, we evaluated obstructions that were 500 mm or 600 mm deep. Based on our results, the depth of an obstruction influenced participants' ability to complete obstructed reaching tasks. A smaller proportion of participants were able to successfully perform reaching across the 600 mm depth obstruction compared to the 500 mm depth (see Figure 13**Figure 13. Percentage of our total participant sample who were unable to complete the various reaching tasks (unobstructed reaching, left; 500 mm depth obstructed reaching, middle; 600 mm depth obstructed reaching, right). Data are summarized for All WhMD users, completing the touch (blue bars) and grasp (orange bars) tasks**). However, among those able to complete the task at both depths, maximum reach heights were generally similar, indicating that obstruction depth evaluated in this study did not substantially affect vertical reach performance once access was achieved. With this in mind, consideration of the lessened obstruction depth (i.e. 500 mm) is recommended for guiding reach range considerations**.** This approach supports greater inclusivity.

  Of note, the ability to complete obstructed reaches was also dependent on whether participants could position their mobility device underneath the table surface, highlighting the importance of the under-surface clearance and device fit.

- ***Comparison with current Canadian standards and codes***
  Similar to unobstructed reaching, a maximum reach height of 1100 mm is recommended when reaching over an obstruction or barrier (e.g. table, counter, 500 mm depth; see Table 4), which generally applies to both forward and lateral directions (exception for ASC 2.3, which provides a lowered general maximum height of 860 mm for a lateral reach – see Table 4). Similar to unobstructed reach ranges, this maximum height may differ for specific elements such as faucets or visual display controls. Based on our collected sample, a maximum height of 1100 mm would accommodate approximately 80% to 87% of participants for touch and grasping tasks in both directions. However, the lowered height of 860 mm for lateral reaching would accommodate 100% of users in our collected sample.

- ***Maximum height when reaching over an obstruction to accommodate 95% of users***
  Similar to unobstructed reaching, recommendations for obstructed reach ranges are based on our laboratory-collected data rather than on bootstrapped estimates, to align with our conservative and inclusive approach to design recommendations. In practice, it may be difficult to anticipate whether a user will adopt a forward or lateral approach. Accordingly, our general recommendations are intended to accommodate both directions. To accommodate 95% of WhMD users in our collected sample, we

recommend a maximum height of ~973 mm, supporting both forward and lateral approaches for both touch and grasp tasks.

4. Implications of space requirements among adult wheeled mobility device users: qualitative report

Alongside anthropometric and functional range assessments and maneuvering space testing, we undertook a qualitative, exploratory study to examine the lived experiences of WhMD users in public spaces. Interviews highlighted how design characteristics of existing environments (e.g., layout, features, spatial constraints) shape maneuverability, use, and navigation of WhMDs.

4.1. Qualitative methods

A subsample of community-dwelling adults who regularly used at least one type of WhMD was recruited to participate in qualitative interviews conducted by telephone or via videoconferencing (MS Teams). Participants were interviewed independently, with each interview session lasting approximately 1 hour. Using a prepared guide, semi-structured interviews focused on gathering one's lived experiences with space-related barriers, facilitators, and general experiences when navigating public spaces. All interviews were recorded and transcribed. Thematic analysis was carried out following Braun and Clarke's methodology (Braun & Clarke, 2006), with analysis being guided by the Social Model of Disability (SMD), and Critical Disability Studies (CSD) (Berghs, Atkin, Hatton, & Thomas, 2019; Goodley, 2014; Meekosha & Shuttleworth, 2009; Neubauer, Witkop, & Varpio, 2019; Oliver, 2013; Rodriguez & Smith, 2018). Following SMD frameworks, analysis focused on participant interactions with the built environment; specifically, how built environment design can create/act as barriers and how they impact their lived experiences. A CDS lens was added to support a focus on understanding how participants encounter ableism and experience disability in public spaces in ways that may be inequitable and exclusionary, and to hold researchers accountable for how they analyze results and share findings (Goodley, 2014; Meekosha & Shuttleworth, 2009).

4.2. Participant demographics

Thirteen participants completed interviews (n = 13). Participant demographics for this sub-sample are summarized in Table 38 below.

Table 38. Summary of participant demographics included in the qualitative interviews

ID	Gender	Age	Community	WhMD(s)	Years w/ WhMD(s)
Participant 1	Female	54	Urban	MWC	2
Participant 2	Female	42	Urban	MWC + PWC	20
Participant 3	Female	53	Suburban	Scooter	10
Participant 4	Male	40	Suburban	MWC	21
Participant 5	Female	68	Urban	Scooter	8

ID	Gender	Age	Community	WhMD(s)	Years w/ WhMD(s)
Participant 6	Male	62	Urban	MWC	< 1
Participant 7	Female	44	Urban	MWC	2
Participant 8	Female	43	Urban	PWC	20
Participant 9	Male	75	Urban	PWC	50
Participant 10	Male	54	Urban	PWC + Scooter	35
Participant 11	Female	61	Urban	Scooter	40
Participant 12	Female	64	Urban	MWC + PWC	35
Participant 13	Male	28	Urban	MWC + PWC	5

MWC, manual wheelchair; PWC, power wheelchair

4.3. Summary of qualitative findings

Participants described their experiences navigating existing public spaces, identifying both enabling and disabling design elements and their impact on device maneuverability and overall user experience. Three key themes emerged, that were specific to afforded space, design, and maneuvering: (1) mental burden of maneuvering in the built environment, (2) accessibility does not include me, and (3) presence of other people (crowding) matters. These themes are summarized below and illustrated with exemplar quotes.

Theme 1: Mental burden of maneuvering in the built environment

When reflecting on their experiences of afforded space and maneuvering, our participants described the burden associated with encountering barriers in public spaces. Although their overall experiences could be described as "enjoyable" (Participant 12), but the presence of spatial design barriers led to fatigue or mental burden associated with maneuvering their WhMDs. One participant described her experience encountering a barrier, tight spaces:

> *"It's mentally and physically exhausting because, because to maneuver my wheelchair in tight spaces so as not to knock over displays or not to get caught on something. So, it, it is more fatiguing. To, to be more vigilant."*
> *— Participant 12 | MWC + PWC | 35 Years of Experience (YE)*

While other participants similarly reported physical burden, they also emphasized the overall mental burden experienced, including frustration. This mental burden was largely attributed to the need for constant problem-solving when maneuvering WhMDs in the built environment, requiring heightened awareness of surroundings and careful attention to how devices were used and navigated. For example, one participant described his careful thought process when maneuvering into and using elevators:

"…it all depends on how fast the [elevator] door shuts and the how, how much force is the [elevator] door has when it shuts. Sometimes it can bang, bang your wheelchair and risk it, risk it working again. And things like getting into the elevator, it all depends on the size of the elevator, the shape. How many people are in it? How many people are coming out? That type of thing."
— Participant 10 | PWC + Scooter | 35 YE

Participants described consistent need to problem-solve across a range of settings, including transition areas (e.g., building entrances and exits), washrooms and washroom stalls, elevators, store aisles, and ramps. Maneuvering challenges were primarily attributed to space design, including limited maneuvering space, layout, and environmental features such as the placement of operational controls (e.g., push buttons), door swing orientation, and the layout beyond doorways. Participants described an expectation to "find a way" (Participant 4) through these environments, even when this required uncomfortable or risky maneuvers. When asked why they would engage in such strategies, our participants shared that they could either adapt through problem-solving or avoid public spaces all together.

"I've really adapted to the barriers because it is it is an able-bodied world. And so in order to be happy living in an able-bodied world, I need to know which paths to take and which paths not to take. Like I, I, I'm the one who's doing the adapting."
— Participant 12 | MWC + PWC | 35 YE

Theme 2: Accessibility does not include me
Maneuvering and experiences in spaces were also influenced by expectations about accessibility. For people who used comparatively larger devices, such as power wheelchairs and scooters, they shared how accessibility often just meant accessible only for people who used manual wheelchairs. Two participants shared their observations about accessible spaces:

"I often find that the, that the spaces that are built for, like, if you're looking at a wheelchair accessible space that you actually know as wheelchair accessible? Uh, they, they will have not, not accounted for the power wheelchair. So, the space is dependent on the manual wheelchair user and not the power wheelchair itself, which can be much larger."
— Participant 2 | MWC + PWC | 20 YE

"people have the best of intentions, but it still wasn't built for me, or I feel like I'm a, a square peg in a round hole."
— Participant 8 | PWC | 20 YE

Feeling out of place can further mean struggling to problem-solve in order to use these spaces or elements. Participant 2 further shared that she felt maneuvering in and using washrooms was most challenging, going so far as to say that "the bathroom is my favorite nemesis"

(Participant 2) because her disability was different than the disability types that accessible washrooms were designed around.

> *"Um, they, every single bathroom stall I've been into with the exception of newer ones, has been the whole concept where […] your toilet is right there and there's a little bit space beside the toilet and you're supposed to be able to somehow transfer from your chair to that toilet, as if you're like an amputee or spinal cord, and like, it's like, okay, but what do I do?"*
> *— Participant 2 | MWC + PWC | 20 YE*

Other participants have shared similar stories, with the placement of some accessible or support elements not being in the correct orientation for them, such as with grab bars, the placement of operating controls (e.g. buttons, light switches) and fixtures. Notably, while participants recognized that the placement or orientation of these features serve as a barrier, they referred to these as barriers only to them. From their perspectives, what is a barrier to them is not necessarily a barrier for someone else.

> *"And, and so again like is, is it accessible? 100%, it's accessible. Is it conducive to my needs? Not necessarily… I mean, it's not configured properly for me. It may be configured properly for somebody else with a disability, you know."*
> *— Participant 4 | MWC | 21 YE*

> *"It's kind of like, I've come to expect it, but that's not how it should be, you know. I, just it's, it's something that I've gotten used to in my daily travels when I'm not home and when I have to go outside in community. I know that I'll have to, um, endure places that are not built for me. So… It's frustrating. It is frustrating. It is frustrating, but then I've kind of I, I've come to accept it. Which—which—which should not be, but it is what it is."*
> *— Participant 8 | PWC | 20 YE*

Theme 3: Presence of other people (crowding) matters

The presence of other people, or crowding, emerged as a third theme influencing maneuvering. Participants reported that challenges arose when navigating public spaces shared with others, noting that spaces that were otherwise accessible or adequately sized became difficult to use when occupied by other people. Crowding was described as "frustrating" (Participant 6) across all WhMD types, with some participants highlighting that it substantially limited their ability to maneuver. One participant shared that:

> *"But I mean it, it's, it's in my experience it's not so much about the space as it is, and I talked about it, the saturation of people around me."*
> *— Participant 4 | MWC | 21 YE*

Crowding is identified as a barrier by users of all WhMD types, from smaller manual wheelchairs to the comparatively larger power wheelchairs and scooters. Participant 7, a manual wheelchair user, emphasized that crowding was a primary factor affecting her maneuverability, stating that:

> *“Because that you have to think about it, but most, it’s enough space if it's empty and you’re the only one in there.”*
> — *Participant 7 | MWC | 2 YE*

Crowding in public spaces effectively reduces the available maneuvering space, making navigation difficult and inconvenient. In addition to these physical constraints, social factors further complicated maneuvering. For example, having to yield to others, wait longer for elevators, or communicate with people (e.g., asking someone to “back out of my way” (Participant 11)) to create space for their devices impacted experiences. The combination of limited space and social interactions was described as “anxiety-provoking” (Participant 3) by one participant. One participant described his typical encounter in grocery aisles:

> *“You know, it's, it's inconvenient for, for both, whoever's in the aisle, or one of us who has to turn around and go back and come around. In most cases the there's usually someone else in the aisle, so I can't go in those stores because it becomes so cumbersome.”*
> — *Participant 9 | PWC | 50 YE*

4.4. Implications of qualitative findings, and impact on recommendations

This sub-study aimed to understand how current and existing environments can impact experiences related to navigation, usability and maneuverability for WhMD users. Participants described and demonstrated how environments that may technically meet accessibility criteria may still present functional challenges, requiring additional physical effort, strategic maneuvering, or cognitive load to navigate successfully. Taken together, these findings identify gaps between technical compliance and lived experiences, and highlight areas requiring greater attention in future accessibility guidelines and standards.

Several key considerations for future accessibility guidance emerged:

- **Design for shared and dynamic use:** Built environments are rarely used in isolation. Crowding and social interaction with other users influence functional space requirements. Designing spaces with flexibility accommodate WhMD users alongside others will enhance usability and inclusion. When considered alongside our empirical laboratory findings, this suggests that environmental spaces designed using conservative space requirement estimates will best serve the broader population.

- **Inaccessible spaces impact not only physical demands, but cognitive loads:** Poor space design shifts the burden of adaptation onto the WhMD users, increasing mental load and impacting participation. Designing spaces that reduce the need for constant problem-solving is therefore essential to create truly inclusive and usable environments.

- **Inclusive design to consider diversity of mobility devices and functional capacities:** Accessibility solutions that work for one individual may not work for another. Accessible design recommendations should recognize variability across device types and user abilities rather than relying on a single representative or “typical” user profile. Recommendations for spaces should not assume average mobility device users and instead accommodate a broad spectrum of needs wherever possible. Consideration of diverse user groups in design recommendations can help ensure that accessible environments best reflect and support the full range of people they are intended to serve.

Part B: Pediatric mobility device users: summary of the state of knowledge related to guidelines for pediatric space design

As part of this project, we aimed to summarize existing guidance related specifically to the pediatric population in the design of the built environment. This included an environmental scan of accessibility standards relevant to the design of child-friendly spaces. In the absence of empirical data collected by our team for this population, we also conducted a rapid literature review to provide a summary of existing resources and literature that may help inform future pediatric-specific built environment design. Ongoing work by our research team seeks to address the current evidence gap by generating empirical data on the maneuvering and reaching capacities of children who use wheeled mobility devices or other assistive devices, analogous to the comprehensive dataset we have developed for the adult population.

1. Environmental scan of literature regarding accessibility guidelines and standards for children and youth

Due to the increasing number of codes and standards related to the built environment across Canada and internationally, an environmental scan was conducted to understand the extent to which pediatric wheeled mobility device users are considered within existing codes and standards. The goal of this environmental scan is to understand: a) if current standards and codes consider pediatric anthropometric measures in the design of spaces, and b) what anthropometric measures are used to guide the design of child-specific spaces. While not exhaustive, the results of this environmental scan may serve as a resource for accessibility codes and standards that provide measurements to guide the design of child-specific spaces within the built environment.

1.1. Search strategy

For Canadian documents, we referred to the publication *A Canadian Roadmap for Canadian Accessibility Standards* (Lau, et al., 2020), which outlines accessibility codes and standards used across Canada. Documents identified in this publication that relate to the built environment were reviewed, and the most current versions of each code or standard were consulted. In addition, the catalogues and databases of codes and standards published by the CSA Group and Accessibility Standards Canada were also reviewed.

We also conducted a search of available grey literature. Search parameters were defined with respect to geographic scope, inclusion criteria, search terms, and screening for relevant sources. Searches were performed using Google Search Engine by adapting the methodology used in other publications (Galipeau & Moher; Parker, Boulos, Visintini, & Ritchie, 2018). All searches were conducted in English, in the fall of 2025, for each geographic area of interest (i.e. Canada, United States, the United Kingdom, and Australia, along with other select international standards). For each search, the first 20 results were reviewed; if the first 20 results contained a relevant document, the next 20 results were reviewed. Relevancy was determined by assessing whether pertinent information (e.g., list of relevant terms) was present in the title of the result (s) and met our defined inclusion criteria. If unclear, a brief search within the document was conducted to determine the relevancy of the identified source.

Different combinations of search terms within the following categories were used to identify relevant documents:

- Context: Buildings, infrastructure, built environment, development committees, advisory councils
- Design requirements: Barrier-free design, inclusive design, universal design, accessibility
- Population: Pediatric, youth, children, children with mobility devices
- Document Type: Standards, codes, policies, regulations

1.2. Eligibility criteria and selection

In order for a document to be eligible for this environmental scan, the following inclusion criteria had to be met:

- Objective: consideration of pediatric anthropometry in design of space requirements
- Population: applicable to children between 2-17 years old
- Document type: code, standard
- Jurisdiction: national-level codes and standards
- Published in the past 20 years (2005-2025)

1.3. Data extraction

Information was recorded for each eligible source, including the context (e.g. public or private settings), geographic region, publication date, and whether the guidance applied to children generally or specifically to children with disabilities. We also documented the specific measurements and values provided (i.e. available technical requirements).

Prior to extracting detailed information, sources were reviewed to determine whether they included pediatric anthropometric, functional, or technical requirements. Specifically, we examined whether references were made to pediatric anthropometric requirements related to any or all of the following:

- Clear floor space (i.e., occupied device length and width)
- Seat depth and seat height (of wheeled mobility devices)
- Knee clearance
- Toe clearance
- Reaching ranges
- Clear width of the path of travel (including doorways)

1.4. Results, environmental scan

A total of 66 sources were reviewed. Of these, only 20 sources were deemed relevant and either reported general functional requirements for children (n = 9) or specific technical requirements (n = 11). Of the 11 sources with technical requirements, only 9 contained technical requirements referencing pediatric anthropometric measures of: clear floor space (i.e. occupied device length and width), seat depth and height (of WhMD), knee clearance, toe clearance, reaching ranges, clear width path of travel (including doorways), and turning area.

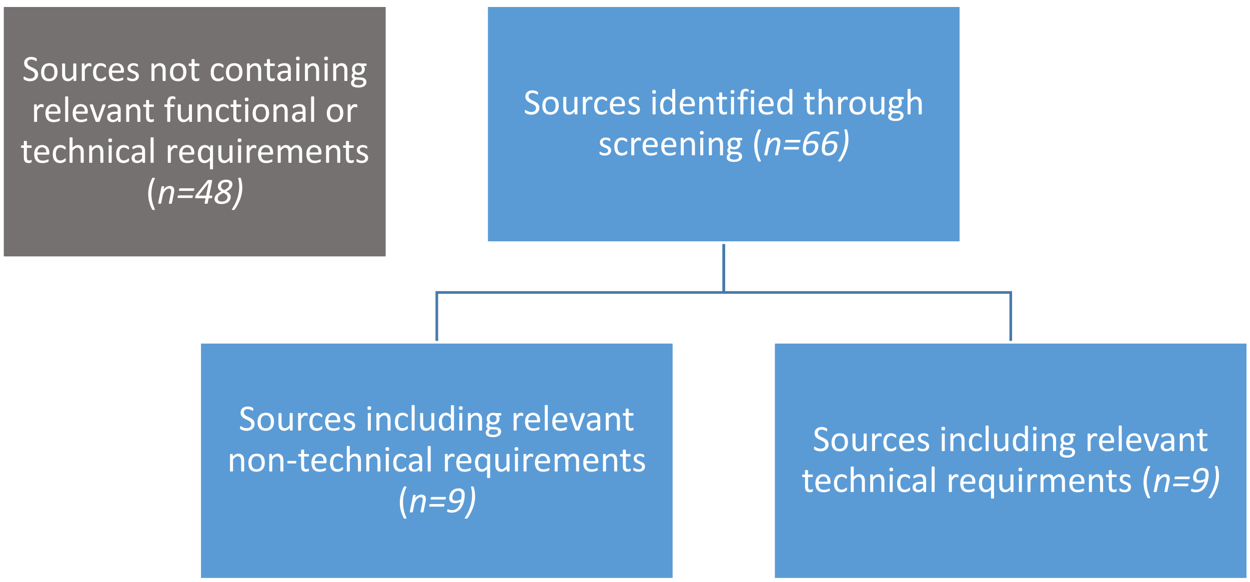

Figure 18. Summary of documents reviewed for inclusion in the environmental scan

The following resources were included in the final set of reviewed materials:

- Canadian Standards Association/Accessibility Standards Canada (2023). *Accessible dwellings (CSA/ASC B652).* Retrieved from https://www.csagroup.org/wp-content/uploads/2430606.pdf
- Canadian Standards Association (2007). *Children's playspaces and equipment standard (CAN/CSA Z614). Annex H: Children's playspaces and equipment that are accessible to persons with disabilities.* Retrieved from https://rfabc.com/wp-content/uploads/2022/08/playspac.pdf
- U.S. Department of Justice (2010). *Americans with Disabilities Act (ADA) Standards for Accessible Design.* Retrieved from https://www.ada.gov/assets/pdfs/2010-design-standards.pdf
- U.S. Access Board (2006). *Americans with Disabilities Act (ADA) Standards for Transportation Facilities.* Retrieved from https://www.access-board.gov/files/ada/ADAdotstandards.pdf

- U.S. Access Board (2015). *Architectural Barriers Act (ABA) Accessibility Standards.* Retrieved from https://www.access-board.gov/aba/
- Canadian Standards Association (2020). *Children's Playground Equipment and Surfacing (CSA Z614).* Retrieved from https://www.csagroup.org/store/product/CSA%20Z614%3A20/
- International Code Council (2017). *Accessible and Usable Buildings and Facilities (ICC/ANSI A117.1).* Retrieved from https://codes.iccsafe.org/content/ICCA117.12017P7
- Accessibility Standards Canada (2023). *Outdoor spaces [draft] (CAN-ASC 2.1)*. Retrieved from https://accessible.canada.ca/creating-accessibility-standards/can-asc-21-outdoor-spaces?mode=full-html
- Accessibility Standards Canada (2026). *Accessible childcare centres [draft] (CAN-ASC 2.9)*. Retrieved from https://accessible.canada.ca/creating-accessibility-standards/can-asc-29-accessible-childcare-centres

1.4.1. Design requirements in the built environment for pediatric populations

Table 39 summarizes the design requirements reported by Canadian and select international sources identified through our environmental scan that inform pediatric-specific built environment space design. Across sources, reaching ranges and knee clearances were the most commonly reported measures specific to pediatric populations and were relatively consistent in their reported values. The reaching ranges provided in these sources refer to unobstructed reaches, with some documents specifying reaching ranges separately for forward and/or lateral reaches. However, no differences were observed in the values provided across these specifications.

Table 39. Summary of guidance for pediatric-specific measurements in reviewed codes and standards

	Requirement	Resource
Clear floor space	760mm wide x 1220mm long	CAN/CSA Z614-07; ADA 2010; ABA 2015; CAN-ASC 2.1
	820mm wide x 1390mm long (single users); 1600mm wide x 1390mm long (two users)	CAN-ASC 2.9
	Accessible water closet compartment for children's use: 1525mm wide and 1500mm deep	ADA 2010; ADA 2006; ICC/ANSI A117.1
	Wheelchair parking beside transfer platform: 1220mm in length	CAN/CSA Z614-07
Seat clearance	N/A	
Knee clearance	610mm x 430mm	CAN/CSA Z614-07; ADA 2010; ADA 2006; ABA 2015; CSA Z614-20; ICC/ANSI A117.1; CAN-ASC 2.1
	For children under 5 years old, no knee clearance is required if the height of the rim surface is not greater than 790mm	CAN/CSA Z614-07; CAN-ASC 2.1
	Height at least 685mm or table height minus 40mm, whichever is less; depth at least 480mm	CAN-ASC 2.9
Toe clearance	305mm above the floor for children's use of an accessible water closet (WhMD user)	ADA 2010; ADA 2006; ABA 2015; ICC/ANSI A117.1
	There should be 205mm of space beyond the stall door	ICC/ANSI A117.1
	Toe clearance is not required if the compartment is more than 1650mm deep	ADA 2010; ADA 2006; ABA 2015
Eye Height	N/A	

Reaching ranges	3-4 years: 510 - 915mm 5-8 years: 456 - 1015mm 9-12 years: 406 - 1120mm	CSA/ASC B652; CAN/CSA Z614-07; ADA 2010; ADA 2006; ABA 2015; CSA Z614-20; ICC/ANSI A117.1; CAN-ASC 2.1
	500 mm and 900 mm above the finished floor with an obstruction of less than 250 mm for all areas where equipment and toys for children are placed	CAN-ASC 2.9
Clear width path of travel	On elevated playground structures: 915mm clear width. A width of 813mm is permitted for 610mm to accommodate features of the structure	CAN/CSA Z614-07; CSA Z614-20
	Clear width path of travel: 1524mm for two wheelchairs to pass side by side, min 914.4 (to make room for path obstructions such as trees)	CAN/CSA Z614-07
Turning area	T-shaped turn: arms and base = 915mm, longest side (top of the T) = 1524mm, height = 1524mm, base is 305mm from the arms on both sides	CAN/CSA Z614-07; CSA Z614-20
	Turning circle: 1524mm diameter	CAN/CSA Z614-07; CSA Z614-20; ICC/ANSI A117.1
	Turning area: 2100 mm diameter	CAN-ASC 2.9

1.4.2. Additional considerations in current standards specific to pediatric design

In addition to the technical requirements that guide the design of pediatric-specific spaces, many accessibility standards include performance-based considerations related to children's use of the built environment. These performance-based considerations are often presented alongside technical requirements as general recommendations rather than prescriptive dimensions. In most cases, the technical requirements themselves are based on data derived from adults, while the accompanying functional statements acknowledge that children may also use these spaces but do not specify how the spaces should be designed to be accessible for them. For example, CSA/ASC B651:23 Accessible Design for the Built Environment notes that *"if a facility is primarily to serve children, dimensions and other provisions should be adjusted to make them suitable for children."* However, the standard does not provide specific guidance on how such adjustments should be made.

Other examples include performance-based guidance for handrails, such as recommendations to provide handrails at multiple heights to accommodate adults, children, and individuals with physical impairments, and to consider installing a second handrail on stairs, particularly in settings such as schools, to support children and people of shorter stature. In outdoor play spaces, the Nova Scotia Built Environment Accessibility Standard Regulation (Government of Nova Scotia, 2025) specifies that clear floor space, turning space, and path widths should provide sufficient clearance to allow children and caregivers to manoeuvre within the space. While this language acknowledges the presence of both children and caregivers, it again does not provide specific dimensional guidance to support design decisions. Collectively, these examples demonstrate that while many standards acknowledge the needs of children functionally, they often do not provide the specific dimensional guidance needed to support consistent and accessible design for pediatric users.

1.4.3. Comparison of pediatric-specific measures and broader recommendations for inclusive space design of the built environment

Our environmental scan indicates that current accessibility standards offer limited pediatric-specific anthropometric guidance for the design of built environments. When pediatric considerations are included, they often differ slightly from our adult-specific recommendations. As an example, for reaching ranges that would guide installation of operating controls, children-specific measures indicate a lower bound of ~406 to 460 mm and upper bound of ~ 1020 mm to 1120 mm (see Table 39). Our adult-derived data suggests a tightened installation range for operating controls based on reaching capacities of WhMD users, with a lower bound of ~860 mm, to an upper bound of ~1015 mm. The emphasis on children to guide reach ranges and seated clearances for children friendly spaces is functionally logical since children have different body proportions than adults, where a reaching envelope with lower minimums may be appropriate to consider.

Conversely, the inclusion of reduced clear floor space requirements for children-specific spaces warrants reconsideration. Current pediatric specific guidance indicates clear floor spaces to be as small as 760 mm x 1220 mm (see Table 39), compared to our minimum recommendations based on adult devices of 845 mm x 1470 mm (with additional tolerances considered for transfer tasks). The recent draft standard CAN-ASC-2.9 (Accessible Childcare Centres) provides improved space recommendations (1600 mm x 1390 mm) that consider a child will be present with a caregiver. A turning circle in children specific documents we identified outlines a minimum space as low as 1524 mm diameter, whereas based on adult devices, a turning area should be at least 2035 mm x 2035 mm if allowing a three-point turn in a space without door location constraints. CAN-ASC-2.9 new version provides a slightly larger turning space (2100 mm diameter), improving upon other children-specific design requirements. While some children use wheeled mobility devices independently, many navigate environments with the assistance of adult caregivers. In these situations, applying adult-based data to guide transfer spaces and clear floor space requirements is functionally appropriate, as it provides greater flexibility for both the child and caregiver when performing tasks. Designing smaller transfer or clear floor spaces specifically for children may therefore be counterproductive. Instead, maintaining dimensions that accommodate adult users can better support the range of real-world use scenarios encountered by children who use wheeled mobility devices and those assisting them.

2. Available sources for guiding space design and operating control recommendations for children and youth

Based on the available accessibility documents described in Table 39 above, we have summarized the resources providing data that underlies pediatric-specific recommendations in our identified accessibility codes and standards. To complement and build on these identified resources, a rapid literature review of academic and grey literature was conducted to identify existing or emerging evidence that could inform future guidance for child-friendly spaces. In the absence of newly collected data, the summarized sources below may serve to guide the development of space and operating control designs that focus on children and youth.

2.1. Resources guiding existing accessibility requirements for pediatric-specific space design

Many of the identified accessibility standards in our pediatric environmental scan draw on one another for the data supporting their recommendations, resulting in similar measurements and specifications across sources.

For reviewed standards (Table 39) that cite a dataset or published resource containing child-specific information to support its development (or utilize a secondary source that includes a published dataset), a summary of that resource is provided below:

- Center for Accessible Housing, North Carolina State University (1992). *Recommendations for Accessibility Standards for Children's Environments.* Report prepared for: Architectural and Transportation Barriers Compliance Board, Washington, D.C.
- Seeger BR, Bails JH (1990). *Ergonomic Building Design for Physically Disabled Young People*. Assistive Technology, *2*(3), 79–92. https://doi.org/10.1080/10400435.1990.10132157

2.2. Rapid literature review to guide pediatric-specific space designs

To further support ongoing work in pediatric space design, we undertook a rapid review of the academic and grey literature to identify data sources reporting pediatric anthropometric measures, with a specific emphasis on children with disabilities. A rapid literature review is a streamlined evidence-synthesis method that allows the research team to quickly identify and summarize existing research on a topic, while maintaining methodological rigour.

For our rapid literature review, we consulted several relevant, academic databases, including Medline, and Scopus. Databases were searched in December 2025. Three individual searches were created, including the following distinct search categories:

- Search #1: Anthropometry (Precise) AND Pediatric AND Ergonomics
- Search #2: Anthropometry (Precise) AND Pediatric AND Mobility Aids
- Search #3: Anthropometry (Broad) AND Pediatric AND Ergonomics AND Mobility Aids

For each search category, relevant terms (e.g. pediatric, children, child, youth, etc.; mobility aids, assistive device, wheelchair, walker, etc.; ergonomics, maneuver, reach range, static measures, function, movement, etc) were included and expanded to ensure comprehensive retrieval of studies related to anthropometric considerations for pediatric populations. For precise searches, terms were searched in title and author keywords only, while broad searches looked for terms within the title, abstract and author keywords. Within the selected search terms, truncation and expansion were applied to capture a broader range of articles within these areas. All searches were limited to articles in English and published after 1980. We also hand-searched relevant literature to identify additional resources related to pediatric anthropometry.

Inclusion and exclusion criteria

To meet the inclusion criteria, articles had to: (1) include children (with or without disabilities), between the ages of 2 to 12 years old, (2) include measures of functional (e.g. reaching) or static (e.g. limb length, stature) anthropometry. Articles were excluded from the rapid review if they: (1) were not in English, (2) included only adults (>18 years old), (3) had anthropometry measures only related to body composition (e.g. skinfold thickness, body mass index), head/facial dimensions or hand size.

A primary focus for inclusion in the rapid review were resources from North America, given their relevance to Canadian standard development, though additional international resources have been included where appropriate.

Article selection
A total of 1390 articles were retrieved from the combined search (752 from Medline, 638 from Scopus). Articles were imported into Covidence and 275 duplicates were removed. Abstracts were reviewed by at least one member of the research team. Of the 1115 articles screened, 39 were selected for full text review, where two reviewers determined final inclusion in the results. A large proportion of articles identified in the rapid review focused on quantifying mismatches between school furniture dimensions and children's seated height. As this body of literature has already been comprehensively synthesized in several systematic reviews, these articles were removed at the abstract review stage and instead the relevant systematic reviews have been included in our final resource list

Grey Literature
In addition to academic literature, we conducted an exploratory, non-systematic search of grey literature using Google Search Engine. This search aimed to capture publicly available datasets, reports, and online resources relevant to pediatric anthropometry. Given its exploratory nature, this component was not conducted systematically but rather served to complement our rapid literature review and ensure that potentially relevant non-academic resources are included in our final results.

2.3. Results, rapid literature review and review of grey literature

The academic and grey literature resources identified through our review are summarized below. Although not exhaustive, collectively these documents provide useful reference points for informing measurements and supporting the ongoing development of pediatric-specific built environment spaces, particularly in the absence of newly collected data focused on children with disabilities who use assistive devices.

North American resources, including children with and without disabilities:

- University of Michigan, Transportation Research Institute (2025) *YouthShape.US* https://youthshape.us/outcomes.html
- Jones MLH, Ebert SM, Miller CS, Park BKD, Jung H, Wood A, Robinson LE, Reed MP (2024). *Laboratory Methods for a Pilot Study of the U.S. YouthShape Survey of Child and Youth Anthropometry and Physical Capability.* Proceedings of the Human Factors and Ergonomics Society Annual Meeting, *68*(1), 193-198.
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International resources:

- Alotaibi RS, Algabbani MF, Shaheen AAM, Albishi AM, Almurdi MM (2024) *Normative values and factors affecting Pediatric Reach Tests in Saudi children aged 6–11 years in the eastern province: cross-sectional study.* Front. Pediatr. 11:1240659. doi: 10.3389/fped.2023.1240659
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Review papers related to design of school furniture for children:

- Arefi MF, Pouya AB, Poursadeqiyan M. (2021). *Investigating the match between anthropometric measures and the classroom furniture dimensions in Iranian students with health approach: A systematic review.* Journal of education and health promotion, *10*, 38. https://doi.org/10.4103/jehp.jehp_516_20
- Castellucci HI, Arezes PM, Molenbroek JFM, de Bruin R, Viviani C. (2017). *The influence of school furniture on students' performance and physical responses: results of a systematic review*. Ergonomics, 6*0*(1), 93-110 https://doi.org/10.1080/00140139.2016.1170889
- Castellucci HI, Arezes PM, Molenbroek JF (2015). *Equations for defining the mismatch between students and school furniture: A systematic review*. International Journal of Industrial Ergonomics, *48*, 117-126.

Review papers related to anthropometric measurements, including children:

- Bragança S, Castellucci I, Costa E, Arezes P, Carvalho M (2020). *Anthropometric data for wheelchair users: a systematic literature review.* Int J Occup Saf Ergon. (1):149-172. doi: 10.1080/10803548.2019.1567974.

2.4. Summary of findings, guidance for measurements applied to pediatric-specific spaces and operating controls.

To date, the inclusion of children-specific, prescriptive measurements in built environment accessibility codes and standards is limited, though performance-based statements are commonly used to support inclusion of children in the absence of specific guiding measurements. Although empirical data guiding children-focused space design is limited, recommendations based on several key documents are widely used likely due to limited alternatives.

In terms of guiding literature and resources, several large-scale anthropometric resources exist for children providing foundational measurements of height, limb lengths, and seated dimensions. These datasets generally form the basis for guiding product development for children, but may have application in accessible design of the built environment for child-specific spaces or design elements. However, no literature was identified that examines functional maneuverability or reaching capacity among children using wheeled mobility devices (e.g. analogous data to our adult-derived functional measures reported in this study). This remains an area of focus in our ongoing work. In the absence of pediatric-specific data, adult-derived recommendations may serve as guidance for determining child-appropriate clear floor, transfer, or turning spaces, though designs should also account for the presence of caregiver–child dyads to best support inclusivity. Given that children's maximum reach capabilities are inherently lower than those of adults, operational controls in pediatric environments should not necessarily follow adult dimensions in a similar way.

Part C: Summary of recommendations, limitations, and future directions

1. Overview of findings

The primary results of this study provide empirically derived data on the physical space requirements and functional reaching abilities of adult wheeled mobility device (WhMD) users in the Canadian context. The findings are intended to support the development and refinement of accessibility requirements within the built environment. Our dataset includes users of manual wheelchairs, power wheelchairs, and mobility scooters, and incorporates functional laboratory-based testing of maneuvering space, clear floor requirements, and reaching capabilities alongside qualitative interviews to better understand the impact of available maneuvering space for the individual.

Our focus of this project was on wheeled mobility device users given that they typically have the largest spatial requirements, which are critical to accommodate in the design of inclusive and accessible built environments. However, we recognize that other individuals with disabilities may also be significantly affected by space constraints. To reflect this, we have collected data from additional representative groups, including people who use walkers or rollators and individuals navigating with guide dogs, to illustrate how our recommendations may influence a broader range of users. While we did not include all potential users of public spaces, these data also provide a valuable foundation for future comparisons with other individuals with disabilities not included in the present work.

In addition to adults, a focus of this work was intended to include pediatric populations. The maneuvering dimensions we present may be applicable to spaces designed specifically for children, as environments that accommodate adult wheelchairs or mobility scooters are generally expected to provide sufficient space for children's mobility devices as well. However, this same principle may not apply directly to the placement of operating controls and other elements where reach ranges may be best informed by the functional reaching abilities of children who use WhMDs rather than adults. Collecting empirical data on children's functional reach is therefore an important direction for future research. Although we planned to gather these data in the current project, recruitment barriers prevented this. Addressing this gap remains a priority for our ongoing work, and we will update our findings as additional data become available.

Overall, the results of this project provide a foundation for evidence-based, harmonized accessibility standards that reflect the diversity of wheeled mobility device users and the functional demands of real-world environments.

1.1. Defining minimum functional space and operating control placement in the built environment

Maneuvering space, clearance space, and access to reachable operating controls are fundamental components of an accessible built environment for people with disabilities. When these elements are insufficient, our interviews highlighted several important considerations. With insufficient space designs, individuals may be required to exert greater physical effort, engage in more complex cognitive planning, or face heightened safety risks in order to complete everyday tasks. In many cases, individuals may also adopt acceptance of inadequate accessibility as part of daily living or reduce their participation altogether.

These challenges underscore the importance of generating empirical evidence to inform improved design standards and practices. A key strength of our work is the focus on functional evaluation, which considers the combined influences of one's preferred body posture, device configuration, and individual reach strategies. This integrated approach provides a more realistic understanding of how wheeled mobility device users interact with their environment and helps support the development of built environments that better reflect users' needs and capabilities.

To date, the development of many current accessibility standards has been informed by earlier datasets considering maneuverability of wheeled mobility devices, including the widely cited work by Steinfeld at al. (2010). Our findings complement and extend this earlier work, by providing updated measurements derived from Canadians, including recommendations that reflect Canadian population device distributions. This is strength of the current dataset. Based on our project findings, the key anthropometric measures and functional space requirements evaluated in this study, along with the recommendations derived from our analyses and their potential applications within accessibility standards and design guidance are summarized in Table 40 below. The recommendations are informed by laboratory-based measurements of wheeled mobility device users performing functional tasks, resampled via bootstrapped estimates to reflect the population distribution of mobility device types in Canada when appropriate. Our recommendations reflect values that accommodate 95% of WhMD users, representing a balance between inclusivity and practical implementation within built environment standards.

Table 40 below is intended to support decision-makers, standards developers, and designers by providing clear, evidence-based guidance on minimum maneuvering spaces, circulation requirements, clear floor spaces, and functional reach ranges. Suggested applications are provided to illustrate how these values may be incorporated into accessibility provisions for elements such as circulation routes, turning spaces, operating control placement, and accessible approaches to fixtures and equipment. While the values presented represent recommended minimum requirements, designers and policymakers are encouraged to consider opportunities to provide additional space in order to improve usability, accommodate device variability, reflect real-world dynamic conditions, and support the presence of additional aids, support persons, or multiple users within a space. Providing space beyond the minimum values improves comfort, flexibility, and safety while reducing the effort required to maneuver. These considerations are particularly relevant in public environments where multiple users and competing spatial demands are common.

Table 40. Summary of recommendations for space and operating control built environment requirements and suggested application in accessibility standards

Dimension/Maneuver	Minimum Recommendations*	Suggested application in accessibility standards**
Occupied width and length	820mm x 1430mm	Clear floor space, transfer space, spaces in seating area, passenger-elevating devices
Occupied area	845mm x 1470mm	Clear floor space, transfer space, spaces in seating area, passenger-elevating devices
Knee clearance (height and depth)	732mm x 393mm	Counters, tables, washroom facilities
Toe clearance (height and depth)	296mm x 268mm	Counters, tables, washroom facilities
Eye height	1065mm - 1320mm	Signage, visual displays, viewing elements
Turning area, continuous turn	2750mm x 2750mm	Interior/exterior accessible routes, ramps, passenger-elevating devices, passenger pick-up areas
Turning area, three-point turn	2035mm x 2035mm	Interior/exterior accessible routes, ramps, passenger-elevating devices, passenger pick-up areas
Turning area, middle entry/exit	2720mm x 2720mm	Doors and doorways, washroom facilities, bathing facilities
Turning area, corner entry/exit	2490mm x 2490mm	Doors and doorways, washroom facilities, bathing facilities
Width of corridor, 90 degree or L-Turn	1135mm	Interior accessible routes, ramps
Width of corridor, turn around a barrier	1280mm	Interior/exterior accessible routes, ramps

Width of corridor, clear path	900mm	Interior accessible routes, doors and doorways
Width of corridor, passing area	1800mm	Interior/exterior accessible routes, ramps, passenger-elevating devices, passenger pick-up areas
Unobstructed reach range	860mm – 1015mm	Operating controls, drinking fountains, washroom facilities, bathing facilities
Max obstructed reach (over 860mm height, 500mm depth)	973mm	Operating controls, drinking fountains, washroom facilities, bathing facilities

**recommendations align with 95th percentile of resampled population using population distributions (exception for reaching ranges); values represent minimum recommended dimensions*

***tolerances added to the minimum recommended values should be considered when applying to functional tasks such as transfers, etc.*

1.2. Value of population-based bootstrapping

A key methodological contribution of this study was the application of bootstrapping analysis, where appropriate, using population distributions of wheeled mobility device types in Canada (Statistics Canada, 2022). Although our dataset included users of several wheeled mobility device types, the sample did not adequately represent the current distribution of device prevalence in Canada. As a result, it was biased toward certain device types and may not fully reflect the broader Canadian population of wheeled mobility device users. Accessibility standards have historically been informed primarily by measurements of manual wheelchair users (Steinfeld et al., 2010), despite the fact that individuals using power wheelchairs may have require greater space (Steinfeld et al., 2010). Bootstrapping of our dataset allowed the study sample to be resampled to reflect the Canadian population distribution of mobility device users, thereby enabling the development of recommendations that (a) better represent the broader population, and (b) are conservative to support inclusive design. This approach helps mitigate potential sampling biases and provides robust percentile estimates that can be to best inform inclusive accessibility requirements.

1.3. Relevance to existing Canadian codes and standards

The findings from this project have direct implications for accessibility requirements across Canadian accessibility codes and standards. At the national level, accessibility provisions are found in multiple resources (e.g. National Building Code of Canada (2025), CSA/ASC B651 (2023), CAN-ASC 2.3 (2025), CAN-ASC 2.1 (2025), CSA B652 (2023)). Comparison of these standards indicates variation in the requirements for circulation, maneuvering space, and operating control placement and highlights the lack of harmonization across Canadian accessibility resources.

When compared to our findings, it is clear that the accessibility provisions within the National Building Code of Canada (2025) are generally insufficient to meet the space requirements suggested by our findings for 95% of wheeled mobility device users. However, the Code provides designers with the option to comply with CSA/ASC B651:23, which offers more comprehensive accessibility guidance. Regardless, changes to the current accessibility standards are still required in for some applications, to better reflect Canadian users of the spaces, and improve inclusive design. Use of the recommendations gathered through this project will support future efforts to harmonize accessibility requirements across national codes, standards, and sector-specific guidelines. Where appropriate, harmonization will benefit inclusive design practices, including those related to transportation systems, housing, heritage spaces, public infrastructure, etc.

1.4. Limitations and future directions

There are several study limitations and associated future directions that must be acknowledged. Firstly, we included a relatively smaller number of mobility scooter users, though users of both three-wheel and four-wheel mobility scooters completed our functional tasks. During recruitment, some individuals who typically use mobility scooters reported that they were unable to travel to the testing site due to accessibility barriers. Others reported choosing to use a different mobility device when traveling longer distances or visiting unfamiliar locations because of environmental accessibility challenges. In these cases, the potentially larger devices (and maneuvering capacities of these larger devices) may not have been captured through our current dataset. These observations further emphasize that limitations in the built environment may restrict the mobility of scooter users, which may inadvertently limit opportunities to collect data that would support improved design.

We encountered significant challenges in our efforts to collect maneuvering capability and reach-range data from pediatric wheeled mobility device users. Over the course of one year, our study team continuously contacted potentially eligible children, via their caregivers. The inability to enroll any pediatric device users during the data collection period represents a substantial limitation of this work. While our maneuvering space requirements collected through adult users may be applicable to children specific spaces (given that our recommendations are based on inclusion of various sized devices), the same may not apply to guidance for operating control installation specifically designed for children’s use. We remain committed to advancing this aspect of the research and are revising our protocols to facilitate easier participation for families. As soon as pediatric data become available, our dataset and associated findings will be updated accordingly and be made publicly available.

Finally, our protocol was carried out in a controlled laboratory environment, where conditions could be optimized and sources of variability minimized. While this approach permitted precise measurement, it did not allow us to incorporate the complexity of real-world settings. Factors such as crowding/the presence and movement of other people, unpredictable obstacles, and the dynamic nature of public environments were not captured in our assessments. Similarly, we were unable to evaluate how our recommendations perform when applied within everyday contexts where environmental demands, competing stimuli, varied spatial layouts, and user priorities may differ substantially from those observed in laboratory conditions. These gaps highlight an important direction for future research. Field-based studies, conducted in environments that reflect the lived experiences of wheeled mobility device users, will be essential for validating our recommendations to ensure their practical relevance and applicability. Regardless, this work serves as a critical foundation for the improvement in accessible space design and guiding harmonization of accessibility standards across Canada.

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Appendix A: Configuration of tested wheeled mobility devices

Within our collected sample, 85% of participants used a wheeled mobility device (WhMD), such as a manual wheelchair, power wheelchair, or mobility scooter. Table A-1 shows the specific configurations of the tested mobility devices and their prevalence within each sub-group.

Table A-1. Description of mobility device configurations

Wheeled Mobility Device Types	N	%
All WhMDs	189	100.0%
Manual Wheelchairs	**70**	**37.0%**
Plus Support Person	4	5.7%
Plus Power Assist Attachment	8	11.4%
Power Wheelchairs	**91**	**48.1%**
Front-Wheel Drive	18	19.8%
Mid-Wheel Drive	60	65.9%
Rear-Wheel Drive	9	9.9%
*Electric Wheelchair**	4	4.4%
Mobility Scooters	**28**	**14.8%**
Three-Wheel Scooter	17	60.7%
Four-Wheel Scooter	11	39.3%

**rear-wheel electric wheelchair (e.g., travel chair, travel buggy)*

Appendix B: Unoccupied vs. occupied measures of device width and length

Occupied measurements (**Error! Reference source not found.**) incorporated the user and therefore reflect the functional fit between the individual and their mobility device (e.g., feet extending beyond footplates, arms extending beyond armrests), as well as personal belongings carried during device use. This approach was chosen to reflect how mobility devices are typically used in community settings, including when accessing public buildings. The unoccupied width and length of the devices were also collected, for completeness of the data, presented in Table A-2 & A-3 below.

Similar to occupied measurements, all unoccupied measurements were collected with the device configured for use, reflecting the participant's typical/preferred positioning during functional activities (e.g. seat tilted back, foot rests extended). Except for participants using front-powered attachments (n=6), unoccupied measurements do not include any additional aids (e.g. service animals, white cane, support person), or removable personal items (e.g. bags, backpacks).

B.1. Unoccupied device width

Unoccupied device width (Table A-2) was measured as the horizontal distance between the most lateral points of the participant's mobility device when unoccupied (e.g., armrests, wheelbase).

Figure A-1. Rear-view image of a scooter. The red, dashed arrows depict an example of the unoccupied measurement (e.g. from arm rest to arm rest, without considering the person)

Table A-2. Unoccupied device width (mm)

Data Source	N	Min	Mean	SD	90^{th} %ile	95^{th} %ile	99^{th} %ile	Max
Laboratory-derived data								
All WhMDs	189	415	661	59	732	758	792	840
Manual Wheelchair	70	520	667	57	740	751	799	840
Power Wheelchair	91	605	670	50	745	773	792	810
Mobility Scooter	28	415	613	71	675	717	727	730
Wheelchairs Only	161	520	669	53	740	765	798	840
Bootstrapped estimates								
All WhMDs	188	415	650	65	727	746	793	840
Manual Wheelchair	102	520	667	57	736	752	802	840
Power Wheelchair	26	605	670	50	738	758	778	810
Mobility Scooter	60	415	613	69	685	713	727	730
Wheelchairs Only	128	520	668	55	737	756	804	840

B.2. Unoccupied device length

Unoccupied device length (Table A-3) was measured as the distance between the furthest anterior and posterior points of the participant’s mobility device (e.g. footplates, seat back) when unoccupied, including the addition of front-power attachments (n=6) if used.

Figure A-2. Side-view image of a scooter. The red, dashed arrows depict an example of the unoccupied measurement (e.g. from front-most to rear-most point on device, without considering the person)

Table A-3. Unoccupied device length (mm)

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	189	775	1115	144	1270	1320	1470	1520
Manual Wheelchair	70	775	1001	129	1135	1148	1281	1505
Power Wheelchair	91	960	1172	96	1285	1320	1438	1465
Mobility Scooter	28	860	1214	132	1362	1429	1501	1520
Wheelchairs Only	161	775	1097	140	1255	1310	1447	1505
Bootstrapped estimates								
All WhMDs	188	775	1092	160	1260	1348	1494	1520
Manual Wheelchair	102	775	1001	128	1135	1149	1311	1505
Power Wheelchair	26	960	1171	95	1282	1323	1376	1465
Mobility Scooter	60	860	1214	130	1361	1435	1499	1520
Wheelchairs Only	128	775	1035	140	1183	1241	1411	1505

Considering the 95th percentile of our sampled wheeled mobility devices, occupied width and length increased by 8.7% and 8.0%, respectively, compared with unoccupied measurements (see Table A-4). Although many standards rely on occupied dimensions, some wheelchair anthropometry studies have used unoccupied device dimensions based on manufacturer-reported make and model specifications (Atkins-Jacobs Joint Venture, 2021). As demonstrated by differences between the 95th percentile values for unoccupied and occupied measures, reliance on device design alone would yield spatial recommendations that underestimate needed space.

Table A-4. Percentage change from laboratory-derived unoccupied to occupied measurements

95th Percentile	Unoccupied Width	Occupied Width	% Change	Unoccupied Length	Occupied Length	% Change
All WhMDs	758	824	8.7%	1320	1425	8.0%
Manual Wheelchair	751	828	10.3%	1148	1220	6.3%
Power Wheelchair	773	823	6.5%	1320	1415	7.2%
Mobility Scooter	717	717	0.0%	1429	1457	2.0%
All Wheelchairs	765	826	8.0%	1310	1371	4.7%

Appendix C: Maneuvering space for residential and private dwellings

For a targeted sub-sample of participants assessed between April 2025 and November 2025, the testing protocol was modified to allow individuals to perform maneuvers related to turning area (i.e. continuous turn, three-point turn, turning area with a varied entry/exit location of a fixed width) until they reached the absolute smallest possible area within which they could successfully complete the maneuver. This approach was implemented to better understand space requirements relevant to the design of residential and private dwellings, rather than public settings, where space constraints are often more restrictive than in public or institutional settings.

All methods have been previously described (3.3.1) however, for this sub-sample, participants continued the maneuver until they made contact with the walls, with no pre-set minimum space imposed. For all measures, descriptive statistics (minimum, maximum, mean, percentiles) are presented in the Tables below, including laboratory-derived data and via bootstrapping analysis using resampled data based on the distribution of mobility devices among the Canadian population. Primary results are presented for WhMD users (manual wheelchairs, power wheelchairs, and mobility scooters) and Wheelchairs only (e.g. excluding scooter users).

Table A-5. Continuous Turning Area (mm), without imposed minimum space restriction

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	96	1150	1752	454	2325	2738	3210	3400
Manual Wheelchair	29	1150	1543	288	1800	1860	2476	2700
Power Wheelchair	40	1250	1528	154	1805	1850	1850	1850
Mobility Scooter	27	1600	2309	424	2900	3110	3348	3400
Wheelchairs Only	69	1150	1534	219	1800	1850	2156	2700
Bootstrapped estimates								
All WhMDs	96	1150	1788	482	2438	2771	3171	3400
Manual Wheelchair	52	1150	1543	282	1783	1993	2442	2700
Power Wheelchair	13	1250	1527	152	1712	1759	1797	1850
Mobility Scooter	31	1600	2308	415	2894	3088	3264	3400
Wheelchairs Only	65	1150	1540	262	1779	1924	2413	2700

Table A-6. Turning area for a three-point turn (mm), without imposed minimum space restriction

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	87	1150	1598	236	1850	2085	2257	2300
Manual Wheelchair	29	1150	1512	207	1720	1860	2044	2100
Power Wheelchair	40	1250	1528	154	1805	1850	1850	1850
Mobility Scooter	18	1500	1894	197	2145	2258	2292	2300
Wheelchairs Only	69	1150	1521	177	1800	1850	1964	2100
Bootstrapped estimates								
All WhMDs	87	1150	1638	263	1990	2113	2253	2300
Manual Wheelchair	47	1150	1513	204	1743	1877	2024	2100
Power Wheelchair	12	1250	1526	152	1706	1753	1792	1850
Mobility Scooter	28	1500	1894	192	2165	2231	2275	2300
Wheelchairs Only	59	1150	1516	195	1746	1864	2019	2100

Table A-7. Turning area with a corner entry/exit (mm), without an imposed minimum space restriction

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	101	1150	1734	373	2200	2400	2750	3200
Manual Wheelchair	31	1150	1558	274	1800	1875	2390	2600
Power Wheelchair	44	1250	1589	204	1885	1950	2057	2100
Mobility Scooter	26	1150	2188	322	2600	2738	3088	3200
Wheelchairs Only	75	1150	1576	235	1850	1950	2230	2600
Bootstrapped estimates								
All WhMDs	101	1150	1762	402	2296	2522	2879	3200
Manual Wheelchair	55	1150	1558	270	1815	1975	2359	2600
Power Wheelchair	14	1250	1589	203	1846	1905	1959	2100
Mobility Scooter	32	1850	2187	315	2592	2782	3000	3200
Wheelchairs Only	69	1150	1564	258	1829	1956	2359	2600

Table A-8. Turning area with a middle entry/exit (mm), without an imposed minimum space restriction

Data Source	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	93	1150	1764	412	2290	2710	2904	2950
Manual Wheelchair	27	1150	1557	272	1820	1885	2344	2500
Power Wheelchair	40	1350	1575	187	1850	1853	2022	2100
Mobility Scooter	26	1850	2269	354	2800	2875	2938	2950
Wheelchairs Only	67	1150	1568	224	1850	1885	2236	2500
Bootstrapped estimates								
All WhMDs	93	1150	1790	440	2456	2717	2886	2950
Manual Wheelchair	50	1150	1557	266	1817	1996	2316	2500
Power Wheelchair	13	1350	1576	186	1805	1859	1908	2100
Mobility Scooter	30	1850	2271	348	2798	2863	2913	2950
Wheelchairs Only	63	1150	1561	252	1824	1954	2310	2500

Summary of recommendations, turning area for residential/private dwellings

- ***Considerations of the users of the space to guide recommendations in residential/private dwellings***
  The purpose of this subsample analysis, in which participants were asked to turn within their true minimum space, was to better understand maneuvering requirements in restricted environments typical of residential settings. Although scooter users were included in the overall dataset, mobility scooters may be less likely to be used within private dwellings. As such, turning space recommendations for home environments may be more appropriately based on wheelchair users (i.e. manual and power wheelchairs)**.**

  Importantly, residential design should also account for caregiver presence and shared maneuvering space, particularly if larger mobility devices (e.g. mobility scooters) are not included in broader recommendations. Though not directly evaluated, the inclusion of mobility scooters in public design guidance is hypothesized to assist (at least in part) with accommodating caregiver support. This should be empirically evaluated in future work. While caregiver space requirements were not directly evaluated in this study, they remain an important consideration when developing accessibility guidance for home environments.

- ***Minimum turning area to accommodate the 95th percentile of wheelchair-only users (manual wheelchairs, powered wheelchairs)***

For spaces without fixed-width doorways: When resampled to reflect the population distribution of wheeled mobility devices, a turning area of approximately 1924 mm x 1924 mm would be required to accommodate 95% all wheelchair users performing a continuous 180-degree turn. However, if a three-point (non-continuous) turn is permitted, a space of 1864 mm by 1864 mm is sufficient to accommodate 95% of wheelchair users. Of note, this recommended space in residential settings would only accommodate ~67% of mobility scooters evaluated in our study for non-continuous turns.

For spaces with smaller, fixed width doorways: When spaces are restricted by a fixed-width doorway, maneuverability is impacted for wheelchair users. When resampled to reflect the population distribution of wheeled mobility devices, the recommended turning area, where entry/exit must occur through a fixed-width doorway (~850 mm), is approximately 1950 mm x 1950 mm to accommodate 95% of all WhMD users (for both a door centrally located, and located to either side of the bounded space).

Appendix D: Turning and space demands of 3- and 4-wheel mobility scooters

Turning performance among scooter users appears to vary according to the number of wheels on the device. In our data, four-wheeled scooters generally demonstrated larger turning requirements than three-wheeled models, likely due to differences in wheelbase configuration, turning radius, and overall frame geometry.

These findings have important implications for accessible design. In environments where four-wheeled scooters are more prevalent, such as outdoor settings or other spaces, where users may prioritize stability and longer duration comfort over compact maneuverability, design specifications may need to account for their increased spatial demands. Individuals often select four-wheel scooters for enhanced stability, for reasons related to body size, personal comfort, or safety on uneven terrain; however, this choice may come at the expense of turning efficiency in constrained indoor environments.

We have summarized the space requirements for three-wheel vs. four-wheel scooters performing the following maneuvers (detailed methods previously described): continuous turn (3.3.1.1), three-point (non-continuous) turn (3.3.1.2), with and without fixed width entry/exits (3.3.2), L-turn (3.3.4.2), and turning around a barrier (0). Descriptive statistics for these maneuvers (minimum, maximum, mean, percentiles) are provided in the Tables below.

Table A-9. Turning area (mm) for 3-wheel (MS_3W) vs. 4-wheel scooters (MS_4W)

Continuous Turn	N	Min	Mean	SD	90th	95th	99th	Max
Mobility Scooters	28	1700	2291	426	2900	3095	3346	3400
MS_3W	17	1700	2074	216	2320	2360	2392	2400
MS_4W	11	1900	2627	458	3200	3300	3380	3400
Three-Point Turn								
Mobility Scooter	28	1700	1832	173	2100	2198	2287	2300
MS_3W	17	1700	1759	105	1850	1900	2060	2100
MS_4W	11	1700	1945	201	2250	2275	2295	2300
Turning area, corner entry/exit								
Mobility Scooter	27	1700	2167	332	2580	2735	3083	3200
MS_3W	16	1700	2053	206	2300	2425	2485	2500
MS_4W	11	1850	2332	415	2750	2975	3155	3200
Turning area, middle entry/exit								
Mobility Scooter	28	1700	2229	372	2800	2865	2937	2950
MS_3W	17	1700	2024	214	2270	2340	2468	2500
MS_4W	11	2050	2545	344	2900	2925	2945	2950

Table A-10. Clear turning width for 3-wheel vs. 4-wheel scooters

Corridor width for L-Turn	N	Min	Mean	SD	90th	95th	99th	Max
Mobility Scooter	28	1000	1041	64	1150	1183	1200	1200
MS_3W	17	1000	1021	31	1050	1060	1092	1100
MS_4W	11	1000	1073	88	1200	1200	1200	1200
Corridor width for U-turn around a barrier								
Mobility Scooter	28	1100	1170	98	1315	1383	1400	1400
MS_3W	17	1100	1132	50	1200	1210	1242	1250
MS_4W	11	1100	1227	120	1400	1400	1400	1400

Appendix E: Tolerances (distance from wall) associated with unobstructed functional reaching

For unobstructed functional reach tasks (touch, grasp), participants performed reaches at a self-selected distance from the wall. The distance between the wall and the nearest point of the participant's device or body was measured and recorded as the tolerance (e.g., distance between toes/device and the board for forward reaches, or armrests and the wall for lateral reaches). Descriptive statistics (means, standard deviation, percentiles) for the measured tolerances are provided below

Table A-11. Unobstructed Reach Tolerances (device/person distance from wall) (mm)

Forward reach, maximum/minimum touch	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	174	0	27	36	80	107	138	180
Manual Wheelchair	71	0	18	30	60	85	123	130
Power Wheelchair	76	0	32	39	83	111	165	180
Mobility Scooter	27	0	39	41	102	109	110	110
Wheelchairs Only	147	0	25	35	77	100	146	180
Walker Users	30	0	30	40	76	108	137	140

Forward reach, maximum grasp	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	176	0	30	43	88	110	173	300
Manual Wheelchair	71	0	25	49	70	110	209	300
Power Wheelchair	78	0	32	36	82	111	165	180
Mobility Scooter	27	0	39	40	102	109	110	110
Wheelchairs Only	149	0	29	43	80	113	175	300
Walker Users	30	0	43	48	121	130	137	140

Left lateral reach, maximum/minimum touch	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	178	0	159	81	292	312	361	370
Manual Wheelchair	69	0	141	69	226	268	321	345
Power Wheelchair	81	0	162	83	290	320	362	370
Mobility Scooter	28	45	196	91	313	327	356	365
Wheelchairs Only	150	0	152	77	271	310	355	370
Walker Users	30	25	162	89	283	316	341	350

Left lateral reach, maximum grasp	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	173	20	177	90	310	354	410	460
Manual Wheelchair	69	30	159	74	242	306	380	400
Power Wheelchair	76	20	183	99	335	373	441	460
Mobility Scooter	28	45	208	94	323	340	360	365
Wheelchairs Only	145	20	172	88	300	358	420	460
Walker Users	30	0	214	97	330	341	386	400

Right lateral reach, maximum/minimum touch	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	181	0	147	78	240	290	367	430
Manual Wheelchair	69	0	128	67	200	252	283	290
Power Wheelchair	84	15	156	83	287	317	366	395
Mobility Scooter	28	50	163	82	222	293	403	430
Wheelchairs Only	153	0	144	77	240	290	344	395
Walker Users	30	10	138	92	271	311	340	340

Right lateral reach, maximum grasp	N	Min	Mean	SD	90th %ile	95th %ile	99th %ile	Max
Laboratory-derived data								
All WhMDs	175	0	177	92	300	362	446	470
Manual Wheelchair	69	0	153	84	262	305	386	410
Power Wheelchair	78	55	190	94	323	369	446	450
Mobility Scooter	28	50	203	98	327	395	459	470
Wheelchairs Only	147	0	173	91	294	354	429	450
Walker Users	30	80	237	99	342	410	450	450

Appendix F: Reach ranges over a 600 mm depth obstruction

As described in 3.4.3 (Obstructed Reach Ranges), participants were asked to complete the touch and grasp tasks over a fixed-height counter/table of two depths: 500 mm and 600 mm. Primary results are presented in 3.4.3 for reaching heights related to the 500 mm depth obstruction. Below, we provide the measured reaching heights for both the touch and grasp tasks, when reaching over the 600 mm depth obstruction.

F.1. Maximum reach heights over 600 mm depth obstruction for a touch task

Table A-12. Maximum forward reaching heights over a 600 mm depth obstruction, for a touch task (mm)

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	129	910	1259	189	1024	974	937	1730
Manual Wheelchair	62	980	1321	178	1067	1041	986	1730
Power Wheelchair	60	910	1213	184	979	960	922	1670
Mobility Scooter	7	970	1106	123	994	982	972	1300
Wheelchairs Only	122	910	1268	189	1035	980	935	1730
Walker Users	27	1040	1411	241	1160	1125	1058	1930
Bootstrapped estimates								
All WhMDs	129	910	1237	188	1010	979	963	1730
Manual Wheelchair	70	980	1321	177	1080	1039	998	1730
Power Wheelchair	18	910	1212	183	1010	980	955	1670
Mobility Scooter	41	970	1105	114	982	972	970	1300
Wheelchairs Only	88	910	1299	184	1056	1014	966	1730

Table A-13. Maximum lateral reaching heights when reaching to the left over a 600 mm depth obstruction (mm), for a touch task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	134	890	1228	183	995	970	922	1680
Manual Wheelchair	60	950	1248	182	1013	989	962	1650
Power Wheelchair	51	890	1192	187	975	928	905	1555
Mobility Scooter	23	1005	1256	170	1072	1057	1016	1680
Wheelchairs Only	111	890	1222	186	990	970	921	1650
Walker Users	23	1130	1499	225	1153	1150	1134	1940
Bootstrapped estimates								
All WhMDs	134	890	1243	178	1017	986	947	1680
Manual Wheelchair	72	950	1248	180	1014	985	963	1650

Power Wheelchair	19	890	1191	185	980	955	931	1555
Mobility Scooter	43	1005	1256	166	1070	1047	1019	1680
Wheelchairs Only	91	890	1236	183	1000	976	940	1650

Table A-14. Maximum lateral reaching maximum heights when reaching to the right over a 600 mm depth obstruction (mm), for a touch task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	130	860	1225	188	990	962	920	1685
Manual Wheelchair	60	940	1254	187	990	980	958	1680
Power Wheelchair	44	860	1197	191	962	925	886	1650
Mobility Scooter	26	960	1207	182	1015	1003	970	1685
Wheelchairs Only	104	860	1230	190	983	961	920	1680
Walker Users	28	1020	1482	215	1201	1161	1054	1900
Bootstrapped estimates								
All WhMDs	130	860	1231	185	999	975	939	1685
Manual Wheelchair	70	940	1254	185	1003	980	959	1680
Power Wheelchair	18	860	1197	188	987	953	922	1650
Mobility Scooter	42	960	1208	179	1015	997	974	1685
Wheelchairs Only	88	860	1242	187	995	972	932	1680

F.2. Maximum reach heights over 600 mm depth obstruction for a grasp task

Table A-15. Maximum forward reaching heights over a 600 mm depth obstruction, for a grasp task (mm)

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	137	900	1275	183	1020	998	947	1720
Manual Wheelchair	64	990	1325	169	1122	1025	1003	1720
Power Wheelchair	64	900	1237	190	1000	980	925	1665
Mobility Scooter	9	1070	1189	138	1078	1074	1071	1510
Wheelchairs Only	128	900	1281	185	1019	994	945	1720
Walker Users	30	960	1402	230	1142	1083	989	1920
Bootstrapped estimates								
All WhMDs	137	900	1269	172	1073	1034	984	1720
Manual Wheelchair	74	990	1325	168	1117	1047	1005	1720
Power Wheelchair	19	900	1236	189	1016	987	960	1665
Mobility Scooter	44	1070	1187	129	1076	1071	1070	1510
Wheelchairs Only	93	900	1307	176	1073	1016	977	1720

Table A-16. Maximum lateral reaching maximum heights when reaching to the left over a 600 mm depth obstruction (mm), for a grasp task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	145	900	1248	175	1010	980	942	1690
Manual Wheelchair	61	980	1283	167	1050	1035	989	1650
Power Wheelchair	60	900	1211	179	980	970	921	1600
Mobility Scooter	24	950	1252	174	1066	1043	971	1690
Wheelchairs Only	121	900	1247	176	1000	980	942	1650
Walker Users	25	1010	1459	244	1152	1108	1032	1960
Bootstrapped estimates								
All WhMDs	144	900	1263	171	1049	1005	958	1690
Manual Wheelchair	78	980	1283	166	1074	1031	994	1650
Power Wheelchair	20	900	1211	177	997	975	952	1600
Mobility Scooter	46	950	1253	171	1065	1026	976	1690
Wheelchairs Only	98	900	1268	170	1045	1002	969	1650

Table A-17. Maximum lateral reaching maximum heights when reaching to the right over a 600 mm depth obstruction (mm), for a grasp task

Data Source	N	Min	Mean	SD	10th %ile	5th %ile	1st %ile	Max
Laboratory-derived data								
All WhMDs	135	900	1258	180	1030	990	950	1715
Manual Wheelchair	62	950	1280	177	1059	1006	974	1715
Power Wheelchair	48	900	1242	186	997	987	928	1680
Mobility Scooter	25	950	1234	175	1041	1007	962	1690
Wheelchairs Only	110	900	1263	181	1029	990	951	1715
Walker Users	28	955	1468	234	1183	1136	1000	1960
Bootstrapped estimates								
All WhMDs	135	900	1259	177	1037	1000	955	1715
Manual Wheelchair	73	950	1279	175	1061	1017	976	1715
Power Wheelchair	19	900	1242	184	1037	1002	966	1680
Mobility Scooter	43	950	1233	172	1034	1002	967	1690
Wheelchairs Only	92	900	1272	178	1049	1004	962	1715

Appendix G: Confidence intervals for bootstrapping analysis

For our bootstrapping estimates, the associated confidence intervals are provided below. The confidence intervals are not intended to guide recommendations, rather to demonstrate the accuracy of our percentile values or the variability present within the population depending on the measurement of interest. A smaller confidence interval (i.e. a smaller range of values) indicates our estimation of the percentile is more accurate whereas a larger confidence interval indicates variability within the population.

The confidence intervals presented below are determined by obtaining the percentile of interest (e.g. 95th percentile) for each of the simulated datasets and analyzing the range within these percentile values. The 2.5th and 97.5th percentile values of these values are determined and provide the upper and lower bounds of the 95% confidence interval.

G.1. Confidence intervals for static measurements

Table A-18. Confidence intervals for the unoccupied device width (mm)

Unoccupied Width	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	188	727	720 - 740	746	730 - 760	793	756 - 840
Manual Wheelchair	102	736	720 - 754	752	739 - 780	802	755 - 840
Power Wheelchair	26	738	693 - 780	758	715 - 800	778	729 - 810
Mobility Scooter	60	685	650 - 720	713	660 - 730	727	714 - 730
Wheelchairs Only	128	737	720 - 755	756	740 - 780	804	759 - 840

Table A-19. Confidence intervals for the unoccupied device length (mm)

Unoccupied Length	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	188	1260	1237 - 1293	1348	1270 - 1450	1494	1398 - 1520
Manual Wheelchair	102	1135	1120 - 1150	1149	1135 - 1180	1311	1150 - 1505
Power Wheelchair	26	1282	1220 - 1390	1323	1234 - 1429	1376	1273 - 1465
Mobility Scooter	60	1361	1270 - 1450	1435	1350 - 1520	1499	1415 - 1520
Wheelchairs Only	128	1183	1150 - 1222	1241	1188 - 1317	1411	1261 - 1505

Table A-20. Confidence intervals for the occupied device width (mm)

Occupied Width	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	187	793	775 - 814	820	799 - 840	864	830 - 904
Manual Wheelchair	101	812	790 - 830	830	810 - 845	863	830 - 890
Power Wheelchair	26	785	738 - 865	818	749 - 950	871	768 - 990
Mobility Scooter	60	700	660 - 720	717	700 - 730	727	714 - 730

Wheelchairs Only	127	810	790 - 825	829	810 - 845	875	830 - 964

Table A-21. Confidence intervals for the occupied device length (mm)

Occupied Length	**N**	**90th %ile**	**Confidence Interval**	**95th %ile**	**Confidence Interval**	**99th %ile**	**Confidence Interval**
All WhMDs	187	1364	1312 - 1390	1430	1384 - 1460	1517	1460 - 1560
Manual Wheelchair	101	1209	1190 - 1220	1234	1210 - 1390	1432	1220 - 1560
Power Wheelchair	26	1349	1290 - 1465	1393	1310 - 1500	1445	1329 - 1510
Mobility Scooter	60	1435	1390 - 1460	1465	1440 - 1520	1504	1454 - 1520
Wheelchairs Only	127	1260	1225 - 1315	1331	1269 - 1423	1483	1347 - 1560

Table A-22. Confidence intervals for the clear floor area (m^2)

Clear Floor Area	**N**	**90th %ile**	**Confidence Interval**	**95th %ile**	**Confidence Interval**	**99th %ile**	**Confidence Interval**
All WhMDs	186	0.95	0.93 - 0.97	1.01	0.96 - 1.09	1.15	1.05 - 1.23
Manual Wheelchair	100	0.94	0.91 - 0.96	0.97	0.94 - 1.04	1.09	0.96 - 1.19
Power Wheelchair	26	1.04	0.94 - 1.20	1.10	0.97 - 1.24	1.17	1.00 - 1.26
Mobility Scooter	60	0.95	0.92 - 0.97	0.99	0.94 - 1.09	1.06	0.97 - 1.09
Wheelchairs Only	126	0.96	0.93 - 1.01	1.01	0.96 - 1.14	1.16	1.03 - 1.24

Table A-23. Confidence intervals for the seat height (mm)

Seat Height	**N**	**90th %ile**	**Confidence Interval**	**95th %ile**	**Confidence Interval**	**99th %ile**	**Confidence Interval**
Wheelchairs Only	156	708	700 – 735	745	711 – 770	787	759 – 821
Manual Wheelchair	125	687	675 – 700	700	685 – 705	707	704 – 710
Power Wheelchair	31	772	750 – 805	788	760 - 823	807	770 - 835

Table A-24. Confidence intervals for the seat depth (mm)

Seat Depth	**N**	**90th %ile**	**Confidence Interval**	**95th %ile**	**Confidence Interval**	**99th %ile**	**Confidence Interval**
Wheelchairs Only	156	815	790 - 840	850	825 - 890	928	877 - 973
Manual Wheelchair	125	806	780 - 836	849	806 - 890	923	870 - 960
Power Wheelchair	31	825	780 - 850	849	805 - 945	893	825 - 990

Table A-25. Confidence intervals for the knee height (mm)

Knee Height	**N**	**90th %ile**	**Confidence Interval**	**95th %ile**	**Confidence Interval**	**99th %ile**	**Confidence Interval**
Wheelchairs Only	155	707	685 - 723	732	710 - 761	787	749 - 831
Manual Wheelchair	124	680	670 - 699	699	680 - 710	717	705 - 725
Power Wheelchair	31	768	730 - 800	787	750 - 833	813	764 - 855

Table A-26. Confidence intervals for the knee depth (mm)

Knee Depth	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
Wheelchairs Only	155	368	355 - 388	393	370 - 410	450	405 - 477
Manual Wheelchair	124	368	355 - 400	392	369 - 410	440	401- 470
Power Wheelchair	31	363	320 - 430	393	340 - 470	432	357 - 485

Table A-27. Confidence intervals for the toe height (mm)

Toe Height	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
Wheelchairs Only	155	273	260 - 280	296	275 - 345	404	321 - 517
Manual Wheelchair	124	258	240 - 270	270	259 - 275	277	274 - 280
Power Wheelchair	31	364	290 - 450	406	323 - 523	464	352 - 595

Table A-28. Confidence intervals for the toe depth (mm)

Toe Depth	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
Wheelchairs Only	155	258	250 - 265	268	260 - 280	290	275 - 307
Manual Wheelchair	124	258	250 - 265	268	259 - 280	289	273 - 300
Power Wheelchair	31	255	240 - 270	264	248 - 293	279	256 - 315

Table A-29. Confidence intervals for the eye height - minimum (mm)

Eye Height	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	188	969	915 - 1059	1065	1050 - 1085	1088	1069 - 1110
Manual Wheelchair	102	951	915 - 1050	1046	940 - 1065	1070	1051 - 1090
Power Wheelchair	26	1045	960 - 1138	1092	985 - 1160	1124	1068 - 1170
Mobility Scooter	60	1096	1090 - 1129	1120	1090 - 1170	1157	1105 - 1200
Wheelchairs Only	128	953	915 - 1053	1052	973 - 1070	1074	1060 - 1090

Table A-30. Confidence intervals for the eye height - maximum (mm)

Eye Height	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	188	1298	1285 - 1310	1319	1305 - 1358	1359	1334 - 1365
Manual Wheelchair	102	1261	1235 - 1294	1287	1255 - 1310	1310	1295 - 1315
Power Wheelchair	26	1319	1278 - 1363	1340	1293 - 1370	1356	1304 - 1375
Mobility Scooter	60	1318	1290 - 1360	1344	1310 - 1360	1358	1336 - 1360
Wheelchairs Only	128	1281	1257 - 1305	1304	1285 - 1315	1343	1309 - 1370

G.2. Confidence intervals for functional maneuvers

Table A-31. Confidence intervals for the continuous turning area (floor) (mm)

Continuous Turning Area (Floor)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	185	2363	2250 - 2550	2752	2400 - 2900	3226	2900 - 3400
Manual Wheelchair	100	1703	1700 - 1800	1761	1700 - 1900	2215	1800 - 2700
Power Wheelchair	26	1712	1700 - 1850	1743	1700 - 1850	1792	1700 - 1850
Mobility Scooter	59	2912	2550 - 3200	3123	2900 - 3400	3335	3026 - 3400
Wheelchairs Only	126	1702	1700 - 1700	1756	1700 - 1850	2166	1800 - 2700

Table A-32. Confidence intervals for the three point turning area (floor) (mm)

3-Point Turning Area (Floor)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	185	1859	1830 - 1900	2035	1850 - 2100	2241	2100 - 2300
Manual Wheelchair	100	1700	1700 - 1700	1733	1700 - 1900	1952	1701 - 2100
Power Wheelchair	26	1711	1700 - 1850	1743	1700 - 1850	1793	1700 - 1850
Mobility Scooter	59	2098	1900 - 2250	2201	2070 - 2300	2278	2163 - 2300
Wheelchairs Only	126	1700	1700 - 1700	1733	1700 - 1850	1945	1700 - 2100

Table A-33. Confidence intervals for the turning area, corner entrance (floor) (mm)

Corner Entrance (Floor)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	176	2252	2150 - 2400	2488	2400 - 2700	2917	2625 - 3200
Manual Wheelchair	95	1714	1700 - 1800	1801	1700 - 1900	2195	1803 - 2600
Power Wheelchair	25	1783	1700 - 1950	1854	1700 - 2070	1944	1738 - 2100
Mobility Scooter	56	2595	2400 - 2750	2798	2488 - 3200	3074	2723 - 3200
Wheelchairs Only	120	1727	1700 - 1800	1823	1700 – 1903	2192	1841 - 2600

Table A-34. Confidence intervals for the turning area, middle entrance (floor) (mm)

Middle Entrance (Floor)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	178	2378	2200 - 2650	2719	2500 - 2800	2901	2800 - 2950
Manual Wheelchair	96	1705	1700 - 1800	1778	1700 - 1900	2145	1800 - 2500
Power Wheelchair	25	1749	1700 - 1850	1802	1700 - 2040	1885	1700 - 2100
Mobility Scooter	57	2802	2650 - 2900	2871	2800 - 2950	2930	2844 - 2950
Wheelchairs Only	121	1708	1700 - 1800	1794	1700 - 1900	2130	1840 - 2500

Table A-35. Confidence intervals for the L-turn (mm)

L-Turn	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	184	1077	1050 - 1100	1135	1100 - 1200	1197	1158 - 1200
Manual Wheelchair	99	1050	1050 - 1050	1064	1050 - 1100	1140	1051 - 1200
Power Wheelchair	26	1057	1000 - 1150	1091	1000 - 1150	1123	1050 - 1150
Mobility Scooter	59	1146	1100 - 1200	1181	1150 - 1200	1198	1171 - 1200
Wheelchairs Only	125	1050	1050 - 1050	1074	1050 - 1100	1152	1088 - 1200

Table A-36. Confidence intervals for the Barrier U-turn (mm)

Barrier U-Turn	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	184	1194	1150 - 1235	1277	1200 - 1350	1389	1309 - 1400
Manual Wheelchair	99	1100	1100 - 1100	1113	1100 - 1150	1168	1101 - 1200
Power Wheelchair	26	1120	1100 - 1150	1138	1100 - 1225	1165	1100 - 1250
Mobility Scooter	59	1327	1250 - 1400	1376	1300 - 1400	1397	1371 - 1400
Wheelchairs Only	125	1101	1100 - 1100	1125	1100 - 1150	1173	1138 - 1238

Table A-37. Confidence intervals for the Clear width path of travel (mm)

Clear Path	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	184	900	900 - 900	902	900 – 942	965	900 – 1008
Manual Wheelchair	99	900	900 - 900	914	900 – 950	967	901 - 1000
Power Wheelchair	26	902	850 - 950	920	888 - 1013	960	900 - 1050
Mobility Scooter	59	850	850 - 850	850	850 - 850	850	850 - 850
Wheelchairs Only	125	900	900 - 900	915	900 - 950	976	900 - 1038

Maneuvering in residential and private dwelling

Table A-38. Confidence intervals for the Continuous turning area, no restriction on minimum space (mm)

Continuous Turning Area (True Min)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	96	2438	2250 - 2775	2771	2400 - 2975	3171	2853 - 3400
Manual Wheelchair	52	1783	1600 - 1900	1993	1745 - 2700	2442	1800 - 2700
Power Wheelchair	13	1712	1550 - 1850	1759	1600 - 1850	1797	1600 - 1850
Mobility Scooter	31	2894	2400 - 3400	3088	2700 - 3400	3264	2885 - 3400
Wheelchairs Only	65	1779	1630 - 1880	1924	1780 - 2700	2413	1850 - 2700

Table A-39. Confidence intervals for the three-point turning area, no restriction on minimum space (mm)

3-Point Turning Area (True Min)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	87	1990	1850 - 2100	2113	1900 - 2250	2253	2100 - 2300
Manual Wheelchair	47	1743	1600 - 1900	1877	1650 - 2100	2024	1800 - 2100
Power Wheelchair	12	1706	1550 - 1850	1753	1573 - 1850	1792	1595 - 1850
Mobility Scooter	28	2165	1960 - 2300	2231	2083 - 2300	2275	2100 - 2300
Wheelchairs Only	59	1746	1600 - 1900	1864	1700 - 2100	2019	1841 - 2100

Table A-40. Confidence intervals for the corner entrance turning area, no restriction on minimum space (mm)

Corner Entrance (True Min)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	101	2296	2100 - 2500	2522	2200 - 2750	2879	2600 - 3200
Manual Wheelchair	55	1815	1700 - 1900	1975	1800 - 2600	2359	1850 - 2600
Power Wheelchair	14	1846	1620 - 2040	1905	1703 - 2100	1959	1750 - 2100
Mobility Scooter	32	2592	2380 - 3155	2782	2400 - 3200	3000	2607 - 3200
Wheelchairs Only	69	1829	1710 - 1910	1956	1800 - 2600	2359	1900 - 2600

Table A-41. Confidence intervals for the turning area, middle entrance, no restriction on minimum space (mm)

Middle Entrance (True Min)	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	93	2456	2200 - 2770	2717	2500 - 2900	2886	2800 - 2950
Manual Wheelchair	50	1817	1700 - 1960	1996	1755 - 2500	2316	1876 - 2500
Power Wheelchair	13	1805	1600 - 2050	1859	1670 - 2100	1908	1700 - 2100
Mobility Scooter	30	2798	2550 - 2950	2863	2733 - 2950	2913	2800 - 2950
Wheelchairs Only	63	1824	1700 - 1900	1954	1800 - 2500	2310	1869 - 2500

G.3. Confidence intervals for reaching ranges

Table A-42. Confidence intervals for the unobstructed forward touch – maximum reaching height (mm)

Unobstructed Forward Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	174	1004	915 - 1079	1103	1053 - 1163	1163	1110 - 1197
Manual Wheelchair	94	1099	1090 - 1147	1139	1100 – 1197	1200	1122 - 1265

Power Wheelchair	24	932	820 - 1072	991	841 – 1146	1049	929 - 1237
Mobility Scooter	56	1072	1050 - 1150	1127	1050 - 1170	1168	1125 - 1220
Wheelchairs Only	118	987	843 - 1092	1100	1053 - 1176	1162	1100 - 1239

Table A-43. Confidence intervals for the unobstructed forward touch – minimum reaching height (mm)

Unobstructed Forward Touch - Minimum	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	174	809	764 - 860	866	820 – 932	982	899 - 1000
Manual Wheelchair	94	652	560 - 735	733	645 - 900	876	716 - 930
Power Wheelchair	24	778	677 - 860	814	731 – 945	859	765 - 960
Mobility Scooter	56	877	820 - 990	948	841 - 1000	991	919 - 1000
Wheelchairs Only	118	704	640 - 770	779	702 - 900	896	782 - 955

Table A-44. Confidence intervals for the unobstructed forward grasp – maximum reaching height (mm)

Unobstructed Forward Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	176	928	860 - 960	1029	956 - 1098	1111	1055 - 1183
Manual Wheelchair	95	989	930 - 1058	1055	1020 - 1110	1111	1054 - 1205
Power Wheelchair	25	876	735 - 985	937	772 - 1110	990	892 - 1137
Mobility Scooter	56	1018	960 - 1188	1141	960 - 1196	1190	1185 - 1200
Wheelchairs Only	120	918	770 - 1020	1017	930 - 1070	1080	1040 - 1150

Table A-45. Confidence intervals for the left unobstructed lateral touch – maximum reaching height (mm)

Unobstructed Left Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	178	958	834 – 1095	1135	1060 – 1227	1243	1155 - 1338
Manual Wheelchair	96	997	900 - 1110	1140	1060 – 1250	1239	1150 - 1340
Power Wheelchair	25	914	780 – 1151	1017	810 – 1216	1112	890 - 1287
Mobility Scooter	57	1199	1130 - 1391	1342	1130 - 1428	1408	1380 - 1470
Wheelchairs Only	121	928	804 - 1069	1098	980 - 1200	1203	1110 - 1260

Table A-46. Confidence intervals for the left unobstructed lateral touch – minimum reaching height (mm)

Unobstructed Left Lateral Touch - Minimum	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	178	679	630 - 715	737	710 - 800	833	780 - 926
Manual Wheelchair	96	539	470 - 655	652	520 - 780	785	680 - 830
Power Wheelchair	25	754	610 - 900	816	656 - 948	883	728 - 980
Mobility Scooter	57	701	640 - 715	728	687- 800	776	712 - 800
Wheelchairs Only	121	627	550 - 725	733	630 - 820	846	766 - 945

Table A-47. Confidence intervals for the left unobstructed lateral grasp – maximum reaching height (mm)

Unobstructed Left Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	172	867	835 - 940	995	890 - 1076	1095	1011 - 1170
Manual Wheelchair	93	867	835 - 1005	992	860 - 1120	1104	1004 - 1220
Power Wheelchair	24	894	850 - 990	933	856 - 1088	980	887 - 1138
Mobility Scooter	55	1040	1010 - 1138	1114	1010 - 1230	1184	1100 - 1260
Wheelchairs Only	117	858	835 - 906	948	860 - 1060	1057	960 - 1144

Table A-48. Confidence intervals for the right unobstructed lateral touch – maximum reaching height (mm)

Unobstructed Right Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	181	944	869 - 1020	1078	1020 - 1220	1221	1130 - 1295
Manual Wheelchair	98	976	880 - 1140	1161	1020 - 1290	1284	1196 - 1361
Power Wheelchair	25	929	825 - 1069	988	852 - 1123	1045	918 - 1250
Mobility Scooter	58	1066	1020 - 1209	1175	1020 - 1366	1261	1180 - 1395
Wheelchairs Only	123	925	837 - 1028	1060	966 - 1220	1199	1057 - 1304

Table A-49. Confidence intervals for the right unobstructed lateral touch – minimum reaching height (mm)

Unobstructed Right Lateral Touch - Minimum	N	90th %ile	Confidence Interval	95th %ile	Confidence Interval	99th %ile	Confidence Interval
All WhMDs	181	669	610 - 720	748	700 - 830	866	798 - 895
Manual Wheelchair	98	567	450 - 630	655	559 - 830	808	634 - 840
Power Wheelchair	25	745	622 - 840	790	672 - 880	834	720 - 890

Mobility Scooter	58	701	640 - 730	753	659 - 895	850	719 - 895
Wheelchairs Only	123	627	566 - 740	739	628 - 830	836	777 - 880

Table A-50. Confidence intervals for the right unobstructed lateral grasp – maximum reaching height (mm)

Unobstructed Right Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	176	860	780 - 943	975	920 - 1050	1069	990 - 1143
Manual Wheelchair	95	888	830 - 970	984	920 - 1092	1077	986 - 1227
Power Wheelchair	25	826	700 - 992	899	732 - 1088	970	830 - 1126
Mobility Scooter	56	990	960 - 1100	1072	960 - 1223	1154	1050 - 1265
Wheelchairs Only	120	843	725 - 930	950	865 - 1048	1040	957 - 1135

Table A-51. Confidence intervals for the obstructed (500mm barrier) forward touch – maximum reaching height (mm)

500mm Barrier Forward Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	146	955	894 - 977	1012	970 - 1065	1077	1040 - 1128
Manual Wheelchair	79	987	935 - 1066	1070	1000 - 1150	1137	1060 - 1210
Power Wheelchair	20	959	860 - 1077	1001	860 - 1149	1045	959 - 1191
Mobility Scooter	47	974	970 - 1014	999	970 - 1082	1049	970 - 1120
Wheelchairs Only	99	957	860 - 1048	1037	969 - 1114	1105	1050 - 1190

Table A-52. Confidence intervals for the obstructed (500mm barrier) forward grasp – maximum reaching height (mm)

500mm Barrier Forward Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	151	977	933 - 1030	1054	1010 - 1080	1086	1070 - 1120
Manual Wheelchair	82	1002	970 - 1062	1069	1010 - 1147	1139	1060 - 1192
Power Wheelchair	21	959	905 - 1056	991	905 - 1080	1027	940 - 1150
Mobility Scooter	48	1075	1075 - 1080	1078	1075 - 1089	1086	1075 - 1116
Wheelchairs Only	103	969	906 - 1030	1032	970 - 1086	1095	1030 - 1160

Table A-53. Confidence intervals for the left 500mm barrier lateral touch – maximum reaching height (mm)

500mm Barrier Left Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval

All WhMDs	152	977	945 - 1008	1035	980 - 1066	1075	1050 - 1110
Manual Wheelchair	82	985	980 - 1037	1025	980 - 1081	1075	1030 - 1142
Power Wheelchair	21	975	945 - 1064	1002	945 - 1090	1034	945 - 1130
Mobility Scooter	49	1061	1050 - 1095	1086	1050 - 1120	1108	1082 - 1140
Wheelchairs Only	103	973	945 - 981	1010	980 - 1060	1060	997 - 1110

Table A-54. Confidence intervals for the left 500mm barrier lateral grasp – maximum reaching height (mm)

500mm Barrier Left Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	156	932	860 - 986	996	970 - 1024	1039	998 - 1110
Manual Wheelchair	84	915	860 - 980	987	940 - 1043	1037	980 - 1112
Power Wheelchair	22	982	935 - 1042	1007	938 - 1058	1031	980 - 1121
Mobility Scooter	50	1002	990 - 1066	1046	990 - 1134	1105	1013 - 1180
Wheelchairs Only	106	919	860 - 980	987	940 - 1029	1028	985 - 1085

Table A-55. Confidence intervals for the right 500mm barrier lateral touch – maximum reaching height (mm)

500mm Barrier Right Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	152	948	891 - 990	1006	965 - 1046	1050	1011 - 1105
Manual Wheelchair	82	977	960 - 1030	1028	965 - 1062	1067	1030 - 1121
Power Wheelchair	21	920	860 - 1012	952	860 - 1070	987	905 - 1095
Mobility Scooter	49	1007	1000 - 1056	1034	1000 - 1119	1086	1008 - 1190
Wheelchairs Only	103	939	861 - 990	996	960 - 1050	1044	995 - 1098

Table A-56. Confidence intervals for the right 500mm barrier lateral grasp – maximum reaching height (mm)

500mm Barrier Right Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	149	954	905 - 990	1009	965 - 1060	1064	1019 - 1110
Manual Wheelchair	80	983	950 - 1020	1030	998 - 1090	1079	1020 - 1133
Power Wheelchair	21	943	900 - 1025	972	900 - 1085	1003	905 - 1110
Mobility Scooter	48	992	965 - 1078	1047	965 - 1124	1099	1025 - 1170
Wheelchairs Only	101	952	900 - 1000	1006	950 - 1075	1050	1015 - 1110

Table A-57. Confidence intervals for the obstructed (600mm barrier) forward touch – maximum reaching height (mm)

600mm Barrier Forward Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	129	963	924 - 970	979	970 - 1010	1010	978 - 1048
Manual Wheelchair	70	998	980 - 1042	1039	990 - 1085	1080	1039 - 1162
Power Wheelchair	18	955	910 - 1043	980	910 - 1075	1010	942 - 1112
Mobility Scooter	41	970	970 - 970	972	970 - 1010	982	970 - 1010
Wheelchairs Only	88	966	910 - 1019	1014	977 - 1060	1056	1015 - 1111

Table A-58. Confidence intervals for the obstructed (600mm barrier) forward grasp – maximum reaching height (mm)

600mm Barrier Forward Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	137	984	929 - 1014	1034	1000 - 1070	1073	1047 - 1100
Manual Wheelchair	74	1005	990 - 1046	1047	1010 - 1150	1117	1020 - 1175
Power Wheelchair	19	960	900 - 1036	987	900 - 1106	1016	948 - 1134
Mobility Scooter	44	1070	1070 - 1074	1071	1070 - 1080	1076	1070 - 1086
Wheelchairs Only	93	977	900 - 1010	1016	990 - 1082	1073	1011 - 1155

Table A-59. Confidence intervals for the left 600mm barrier lateral touch – maximum reaching height (mm)

600mm Barrier Left Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	134	947	902 - 977	986	970 - 1012	1017	990 - 1060
Manual Wheelchair	72	963	950 - 990	985	961 - 1020	1014	990 - 1080
Power Wheelchair	19	931	890 - 1001	955	890 - 1030	980	918 - 1048
Mobility Scooter	43	1019	1005 - 1070	1047	1005 - 1081	1070	1015 - 1110
Wheelchairs Only	91	940	890 - 970	976	950 - 1003	1000	970 - 1050

Table A-60. Confidence intervals for the left 600mm barrier lateral grasp – maximum reaching height (mm)

600mm Barrier Left Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	144	958	922 - 986	1005	976 - 1045	1049	1010 - 1105
Manual Wheelchair	78	994	980 - 1035	1031	993 - 1101	1074	1028 - 1120
Power Wheelchair	20	952	900 - 1004	975	900 - 1063	997	935 - 1110

Mobility Scooter	46	976	950 - 1049	1026	950 - 1080	1065	995 - 1108
Wheelchairs Only	98	969	900 - 995	1002	979 - 1048	1045	995 - 1114

Table A-61. Confidence intervals for the right 600mm barrier lateral touch – maximum reaching height (mm)

600mm Barrier Right Lateral Touch - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	130	939	877 - 970	975	960 - 1000	999	980 - 1030
Manual Wheelchair	70	959	940 - 980	980	956 - 1000	1003	979 - 1080
Power Wheelchair	18	922	860 - 1050	953	860 - 1062	987	902 - 1077
Mobility Scooter	42	974	960 - 1010	997	960 - 1030	1015	1000 - 1041
Wheelchairs Only	88	932	860 - 972	972	940 - 990	995	974 - 1066

Table A-62. Confidence intervals for the right 600mm barrier lateral grasp – maximum reaching height (mm)

600mm Barrier Right Lateral Grasp - Maximum	N	1st %ile	Confidence Interval	5th %ile	Confidence Interval	10th %ile	Confidence Interval
All WhMDs	135	955	917 - 993	1000	957 - 1034	1037	1000 - 1079
Manual Wheelchair	73	976	950 - 1022	1017	980 - 1090	1061	1005 - 1103
Power Wheelchair	19	966	900 - 1094	1002	900 - 1117	1037	960 - 1138
Mobility Scooter	43	967	950 - 1021	1002	950 - 1050	1034	960 - 1075
Wheelchairs Only	92	962	900 - 999	1004	972 - 1055	1049	1000 - 1100