ARUP

Department for Levelling Up, Housing and Communities (DLUHC)

Access to and use of buildings – research on demographics and ergonomic requirements (Part M Research)

Final Report

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Executive Summary

This Part M research was undertaken to understand the requirements of the population in England in relation to the built environment, in particular disabled people and people with long-term health conditions, to inform a possible update to Approved Document M (ADM) (Volumes 1 and 2) which provides statutory guidance on how to meet requirements in Part M of the Building Regulations.

The key aims of the research were to:

- Understand what current evidence, data and research exists about the population in England, in particular disabled people and people with long-term health conditions.
- Produce new, up-to-date experimental and qualitative data, about the requirements of disabled people and people with long-term health conditions.
- Provide findings and identify recommendations or areas for future research for the Department of Levelling Up, Housing and Communities to consider as part of any updates to ADM Volumes 1 and 2.

A summary of the research methodology, key findings and next steps are provided below.

Research methodology

Literature and data review

A thorough review of existing published literature and data was undertaken to establish the most current and available demographic and disability data for England, including mobility aid use and anthropometric and ergonomic data, as well as identifying future trends in disability and mobility aid use, and the impact of this in relation to current standards and guidance for the built environment.

Survey, interviews and focus groups

A qualitative research study was undertaken to understand both the barriers and helpful features of the built environment for disabled people and people with long-term health conditions. This involved an online survey and structured interviews, and a series of targeted focus groups to gain further insight into the experience of certain groups.

Wheelchair data

A quantitative research study was undertaken to collect experimental data on wheeled mobility aids, specifically the dimensions on static wheeled mobility aids and percentile manoeuvring space dimensions of wheeled mobility aids, to understand how this compares to previous research studies and current design guidance in England.

Specific project studies

- Reach ranges
  - A quantitative research study was undertaken to collect experimental data on reach ranges for people in wheeled mobility aids, specifically looking at reach ranges for everyday activities such as posting and picking up letters and reaching switches and sockets to operate controls to understand how this compares to current guidance.

- Opening forces
  - A quantitative research study was undertaken to collect data on opening forces, motor skills, strength and space required to open and use doors window and operate buttons. This included experimental data on the space required to reach and operate handles, and the strength required to operate controls to understand how this compares to current guidance.
- Ramp study
  - A quantitative research study was undertaken to collect experimental data on ramp gradients and the tipping point range of unoccupied and 'occupied' wheeled mobility aids to inform the design of ramps.
  - A qualitative user survey was also undertaken to collect data on ramp gradients and disabled people's experience of using ramps.

Key findings

Disability prevalence

- Available data on the prevalence of different disabilities is inconsistent and likely to under-represent the actual prevalence of disability in many cases.
- The rate of co-occurrence of multiple disabilities, and the rate of use of multiple different types of mobility aid, in a single person appears to be high. Current surveys collecting information about disability do not reflect this, as they do not allow people to report multiple, distinct conditions.
- There is no centralised data source to understand the prevalence of different types of mobility aid (e.g. manual and powered wheelchairs) in the population of England.

User experience

- Findings from the qualitative research indicate the built environment is, in general, not meeting the needs of disabled people and people with long-term health conditions.
- More than 50% of respondents of the non-residential survey described the built environment as 'highly unsatisfactory', while less than 10% described it as 'highly satisfactory'.
- The inaccessibility of the built environment presents a serious barrier to many disabled people to participate fully in life. Many respondents also reported an inability to participate and use many spaces, or a sacrifice to health, safety or comfort in order to use inaccessible spaces, with more than 10% of the total survey respondents reported that they had not been able to participate in an activity outside their home in the past week.
- Many disabled people expressed frustration at a lack of thought given to accessibility in design of the built environment and a lack of 'joined-up' thinking across design. The cost of making spaces accessible, and the difficulty of accommodating multiple different needs, were identified as reasons why a lack of access may exist.
- Issues of non-compliance and enforcements were raised with the opinion that there was limited pressure and enforcement on designers or building owners to comply with the regulations and standards that exist.

- This is coupled with a lack of provision in standards for particular access needs beyond mobility and space requirements.
- Improving accessibility information about places in advance, user-testing designs with disabled people, meaningful consultation with disabled people and more 'joined-up' thinking across design were also highlighted as ways to improve the accessibility of the built environment.

Space dimensions for wheeled mobility aids

- Based on the data collected for stationary, occupied wheeled mobility aids, the current spatial dimensions provided in ADM (Volume 2) (e.g. 900mm x 1400 mm 'footprint') would accommodate most wheeled mobility aids (82% of all wheeled mobility aids).
- Previous surveys of occupied mobility aids have collected only static data. This survey included collection of manoeuvring space for occupied wheelchairs to turn, with a significantly higher sample size for these data points than previous studies. The data indicates that the 90th percentile turning space dimensions for wheelchairs are significantly higher than previous research suggests, and the current guidance in ADM (Volumes 1 and 2) (e.g. 1500mm x 1500mm) recommends.
- Based on the data collected in this study, a 1500mm x 1500 mm turning square will accommodate 42% of all wheeled mobility aids users making a 90º turn, and 27% making a 180º turn. However, this varies by wheeled mobility aid type:
  - 62% of manual self-propelled mobility aid users made a 90º turn and 46% a 180º turn within 1500mm x 1500mm.
  - 34% of powered mobility aid users made a 90º turn and 16% a 180º turn within 1500mm x 1500mm.
  - 12% of attendant-propelled mobility aids made a 90º turn and 5% a 180º turn within 1500mm x 1500mm.

Application of built environment standards

- Reach ranges
  - Based on the data, the -24° front reach ranges for height are closer to finished floor level (FFL) than currently suggested in guidance. The +70° reach measures are also higher than currently suggested in guidance.
  - For side reach, the -24° reach ranges for height are higher from FFL than currently suggested in guidance. The +70° reach measures like for the front are higher than currently suggested in guidance.
  - For depth, the data suggests that from the front many cannot reach past the front edge of their wheelchair. However, side reach data +70° measurements align loosely with current recommendations in BS 8300-2:2018 for both comfortable and extended reach. The -24° measures are also larger than currently recommended in BS 8300-2:2018.
  - Based on the data collected, current guidance for picking up and posting letters aligns with the front horizontal plane 5th and 95th percentile values.
  - For letter cage depth, a depth range of -418mm – 247mm / -41.8cm – 24.7cm (i.e. 5th and 95th percentile values) was identified. However, it is suggested future testing is completed to supplement this data with a focus on ambulant disabled participants,

particularly reviewing the lower ranges as this was not in the scope of this research but should be explored going forward.

- Door and windows:
  - Approach
    - Based on the data, more space may be required for general approach widths to doors and windows than currently suggested in ADM (Volumes 1 and 2) and BS 8300-2:2018, with approximately the 5th percentile of participants accommodated by current guidance.
    - Left- hand use required a larger overall approach width than right-hand use.
  - Forces:
    - When looking at anterior (front) and lateral (side) approaches considering push, pull and downward motions on the door handle, the data collected for the 5th percentile showed that for all motions the forces were lower than the current recommended from ADM (Volumes 1 and 2) and BS 8300-2:2018 guidance of 30N maximum force for opening a door from 0-30° and 22.5N.
    - However, the 5th percentile values for pull force for both anterior (front) and lateral (side) were larger than the 22.5N maximum for opening a door from 30° - 60 ° as per both ADM (Volumes 1 and 2) and BS 8300-2:2018.
    - While the 5th percentile value for the lateral (side) down force was 36.0N, the 5th percentile value for down forces suggests that the force required to push a handle down should not exceed 18.7N for front forces which is lower than the door force recommend in current guidance.
- Ramps and gradients:
  - Tipping point study
    - Based on the tipping data collected, the gradient at which tipping occurs is shallower for all 'occupied' wheeled mobility aid types than for an unoccupied wheeled mobility aid.
  - Ramp study
    - Based on the data collected, ambulant disabled people and wheeled mobility aid users experience gradients differently, with preferred steepness and length of ramps, and comfort and effort used to use ramps varying by individual.
    - Generally, most wheelchair users showed preference for shallower and shorter ramps.

Conclusion

- The findings from this research indicates the spatial dimensions for access provided in current guidance, including ADM (Volumes 1 and 2), are generally too small for a wide range of disabled people and people with long-term health conditions.
- Disabilities are often treated separately in design guidance, but co-occurrence of disability is high. Disabled people often also use more than one type of mobility aid. This means disabled people's spatial needs are complex. Despite this, designing for access tends to focus primarily on independent wheeled mobility aid users.

- This research indicates that people's spatial needs are also significantly influenced by other factors, including being accompanied by companions (e.g. assistants; family; children etc.); personal adaptation / additions to wheeled mobility aids; using additional mobility aids simultaneously; individual manoeuvring and transfer style etc.
- While a significant number of the key items generally limiting access to the built environment are currently not included within the guidance in ADM (Volumes 1 and 2), they are included in BS 8300 Parts 1 and 2 (but BS 8300 does not currently have statutory control).
- Consequently, significant numbers of disabled people appear to 'put up' with non-accessible spaces, or completely avoid them – people tend to have a good idea of where they can and cannot go. This means access issues with design are likely to go unaddressed.
- For robust studies, accurate and representative population samples / sampling methods are required. However, currently, much of the needed data does not exist. Where data is available, this generally does not capture the complexity of disabled people's requirements (e.g. knowing someone has a mobility disability does not identify whether they use a wheeled mobility aid) or record the number of mobility aids they may own and use.
- While a useful starting point to inform a possible update to ADM (Volumes 1 and 2) of the Building Regulations, the data in this research is not comparable to our understanding of design for non-disabled people; this is a problem that needs to be addressed holistically to best understand what is required to provide an accessible built environment.
- Focused ergonomic studies that consider both how we design specific spaces (e.g. sanitary facilities, kitchens, etc.) and the features of the built environment (i.e. ramps, doors, and controls etc.) also need to be conducted with a range of actual users - rather than extrapolated from anthropometric data - and co-designed with users, to build up more robust guidance.

Future research recommendations

Demographic data and disability prevalence

- Data collection to fill data gaps and improve the accuracy of existing data. Key areas relevant to the design of the built environment include:
  - Current and future projections (for the next 5, 10 and 20 years) of population demographics, predicted numbers of disabilities and long-term health conditions, including neurodivergence and mental health conditions, sensory disabilities and learning disabilities.
  - Research on the co-occurrence of disabilities and the prevalence of disability and long-term health conditions within different demographic groups, including ethnic groups, and older and younger people.
  - Number of people with assistance animals / emotional support animals.
  - Number of pregnant people at any one time, and to consider how pregnancy prevalence interacts with disability. Further medical or qualitative research to understand how different stages of pregnancy create different accessibility needs in the built environment.

  - Estimated population who would benefit from the space and / or facilities provided by Changing Places toilets.
  - Estimated population requiring assistance. Research could also be conducted in public locations to understand the number of people who travel with assistance or require assistance outside their homes.
  - Estimated population who have caring for children responsibilities and research to understand how the care of children impacts on the built environment, whether in people's homes or in buildings other than dwellings.
- Improving data collection methods to:
  - Allow people to identify themselves more accurately in surveys and research – e.g. allowing respondents to select multiple disabilities or health conditions to identify disability prevalence more accurately in the population.
  - Clarify definitions e.g. what is meant by illness, to improve the accuracy and comparability of data.

Ergonomic data

- Future rolling ergonomic studies to understand both the prevalence of, and to consider the needs of:
  - Wheelchair and wheeled mobility aid users.
  - Ambulant disabled people and semi-ambulant mobility aid users.
  - People with limited strength and dexterity.
  - People with assistance animals.

Building data

- Data collection to understand the existing and proposed / future building stock in England. Key areas relevant to accessibility include:
  - Number and distribution of M4(3) Category 3 Wheelchair user dwellings and M4(2) Category 2: Accessible and adaptable dwellings.
  - Number and distributions of accessible parking facilities (as per the current requirements of ADM Volume 2).

Specific research projects

- Establishing manoeuvrings spaces required for a wider range of people including those using mobility aids such as walking frames or long canes, and guide dogs. Including space to pass and travel a set distance.
- The effectiveness of Light Reflectance Values and the relative light levels needed to ensure sufficient contrast is provided for a wide range of users
- A review of the height and design of door thresholds and the impact of their design on wheelchair users and a wide range of disabled people
- Toilet design and the layouts and facilities required by a wide range of disabled people. This should include positioning of the basin in relation to the WC pan and the availability and use of grab rails.

- Reach range data to inform use of specific facilities such as petrol pumps and electric charging points.
- Reach ranges for ambulant disabled people focusing on heights, in particular the lower end of the reach range and the use of letter boxes and picking up letters.
- Further study to assess the depth of reveal that can be provided to doors to allow access to handles (currently not specified in guidance except in ADM Volume 1 for a M4(3) Category 3: Wheelchair user dwelling).
- Data sets for experimental research to identify users' wheeled mobility aid type (i.e. self-propelled or powered) and co-occurrence of disabilities to explore if this has any impact on results (e.g. operation of doors impacted by users' wheeled mobility aid type).
- Research into the use of door and window handle types / profiles, including locking facilities, and suitability of current guidance on handle design.
- Research into the use and operation of sliding doors and the space requirements to operate.

Contents

Glossary of terms

- **Accessible:** with respect to buildings or parts of buildings, means that people, regardless of disability, age, sex or gender, are able to gain access.
- **Ambulant mobility aid:** any mobility aid which is designed to support a walking user, including crutches, walking frames and walking sticks.
- **Anterior:** positioned or going to the front.
- **Anthropometric:** scientific study of the measurements and proportions of the human body.
- **Approach width:** largest width required to approach a point of reference.
- **Attendant-propelled mobility aid:** a wheelchair that is propelled by another person, or attendant, typically standing behind the wheelchair and pushing the handles.
- **Blue Badge:** a parking badge scheme in England that allows eligible disabled people and / or people with health conditions to park closer to their destination, either as a passenger or driver.
- **Breadth:** refers to the dimension of a figurative space (i.e. a manoeuvring space).
- **Changing Places toilet:** a large, multi-use toilet / changing facility incorporating a hoisting system and adult changing bench, designed for people who may need assistance from other people to use sanitary facilities.
- **Co-occurrence of disability:** the presence of multiple different conditions or categories of disability in a single person – for example, someone who has both sight and hearing loss.
- **Ergonomic:** refers to design that provides and comfort relating to the dimensions and proportions of the human body.
- **Gender:** a social construction relating to behaviours and attributes based on labels of masculinity and femininity; gender identity is a personal, internal perception of oneself and covers a wide range of genders including non-binary.
- **Gentle slope:** gradient between 1:60 – 1:20.
- **Hybrid mobility aid:** a wheelchair that combines powered operation and manual operation, such as a manual wheelchair with an additional power source attached to the back.
- **Independent-use wheeled mobility aid:** any wheelchair that is controlled and operated by the occupant, rather than another person, whether this is through manual operation or use of controls on a powered chair.
- **Lateral:** positioned or going to the side**.**
- **Level:** gradient not exceeding 1:60.
- **Manoeuvring space:** clear floor space required for an individual (including mobility aid user) to turn (typically indicated in this report as a square with length and breadth).

- **Mobility scooter:** an electrically-powered scooter used in a seated position.
- **Neurodiversity:** variations in human brain function and behavioural traits, for instance in sociability, learning, attention, mood and other mental functions.
- **Percentile:** a percentile is a measure used in statistics which indicates the value below which a given percentage of observations in a group of observations fall.
- **Photogrammetric study:** study designed to obtain information about the size of physical objects by taking measurements from multiple photographs, calibrated to provide accurate dimensions.
- **Posterior:** positioned or going to the back**.**
- **Powered mobility aid:** a wheelchair that is propelled by a power source / motor, rather than being manually propelled by the occupant. Typically this will be operated through controls, either handheld or attached to the wheelchair.
- **Qualitative data:** refers to data that cannot be objectively measured or counted – usually obtained first-hand via interviews, focus groups, surveys etc.
- **Quantitative data:** generally refers to numerical data that can be objectively measured or counted.
- **Ramp:** a gradient between 1:20 and 1:12.
- **Rehabilitation buggy:** a Child Transportation Device that provides additional support, typically for disabled children, often providing postural support.
- **Self-propelled mobility aid:** a wheelchair that is manually propelled by the occupant, typically by using the arms to propel the wheels.
- **Sex:** refers to the biological aspects of an individual as determined by their anatomy, which is produced by their chromosomes, hormones and their interactions (e.g. male or female).
- **Slope:** inclined surface with a gradient steeper than 1:60 and shallower than in 1:20.
- **Wheeled mobility aid:** overarching term for all wheelchairs and wheeled aids for personal transport, including mobility scooters, powered and non-powered (manual) wheelchairs.
- **Width:** refers to the dimension of a tangible space (i.e. width of a person).

1. Introduction

1.1 Context

Arup was appointed in March 2021 by the Department for Levelling Up, Housing and Communities (DLUHC), previously Ministry for Housing, Communities and Local Government (MHCLG) to carry out research into the requirements of the population of England in relation to the built environment, in particular disabled people and people with long-term health conditions. The intention of this research is to inform an update to Approved Document M (Volumes 1 and 2)[1] which provides statutory guidance on how to mee the requirements of Part M of the Building Regulations.

This research was supported by subconsultants at both Loughborough University (LU) and The Occupational Therapy Service (TOTS) that collected all experimental data for the research (through photogrammetric and qualitative studies) and contributed to and peer reviewed all Interim Reports.

Throughout the project, Arup has consulted with DLUHC and with the project's Technical Steering Group (TSG), an expert panel of accessibility, ergonomics and built environment specialists. Methodology and Interim Reports have been provided at project milestones to DLUHC and the TSG for review, comment and discussion.

In some instances, the originally intended methodology for this research was adapted (e.g. where data was not available, due to extraneous circumstances impacting data collection, such as the Covid-19 pandemic, etc.) Where the originally intended methodology was revised, this has been noted in the relevant section of this report.

The purpose of this research study is to provide a broad evidence base to inform a future update to Approved Document M (Volumes 1 and 2) by:

- Understanding what current evidence, data and research exists;
- Producing new, up-to-date experimental and qualitative data, and;
- Providing recommendations for future research projects and items that could fill gaps in existing data.

The research was split into 3 Objectives consisting of 12 Research Streams in total (see Figure 1). The Objectives are as follow:

- Objective 1: Literature and data review to establish the current evidence base and identify gaps in knowledge (see Section 2).
- Objective 2a and 2b: Data collection, including qualitative data collection and quantitative ergonomic and anthropometric data collection (see Section 7 and 11).
- Objective 3: Focus studies, collecting data to support three priority research areas identified by DLUHC (see Section 14).

[1] Approved Document M: Access to and use of buildings - Volume 1: Dwelling (2015, incorporating 2016 amendments) and Approved Document M: Access to and use of building - Volume 2: Buildings other than dwellings (2015, incorporating 2020 amendments).

This final report evaluates the findings, implications, and impacts of this research in the context of Approved Document M (Volumes 1 and 2). The report concludes with a set of next steps for future research informed by the research findings.

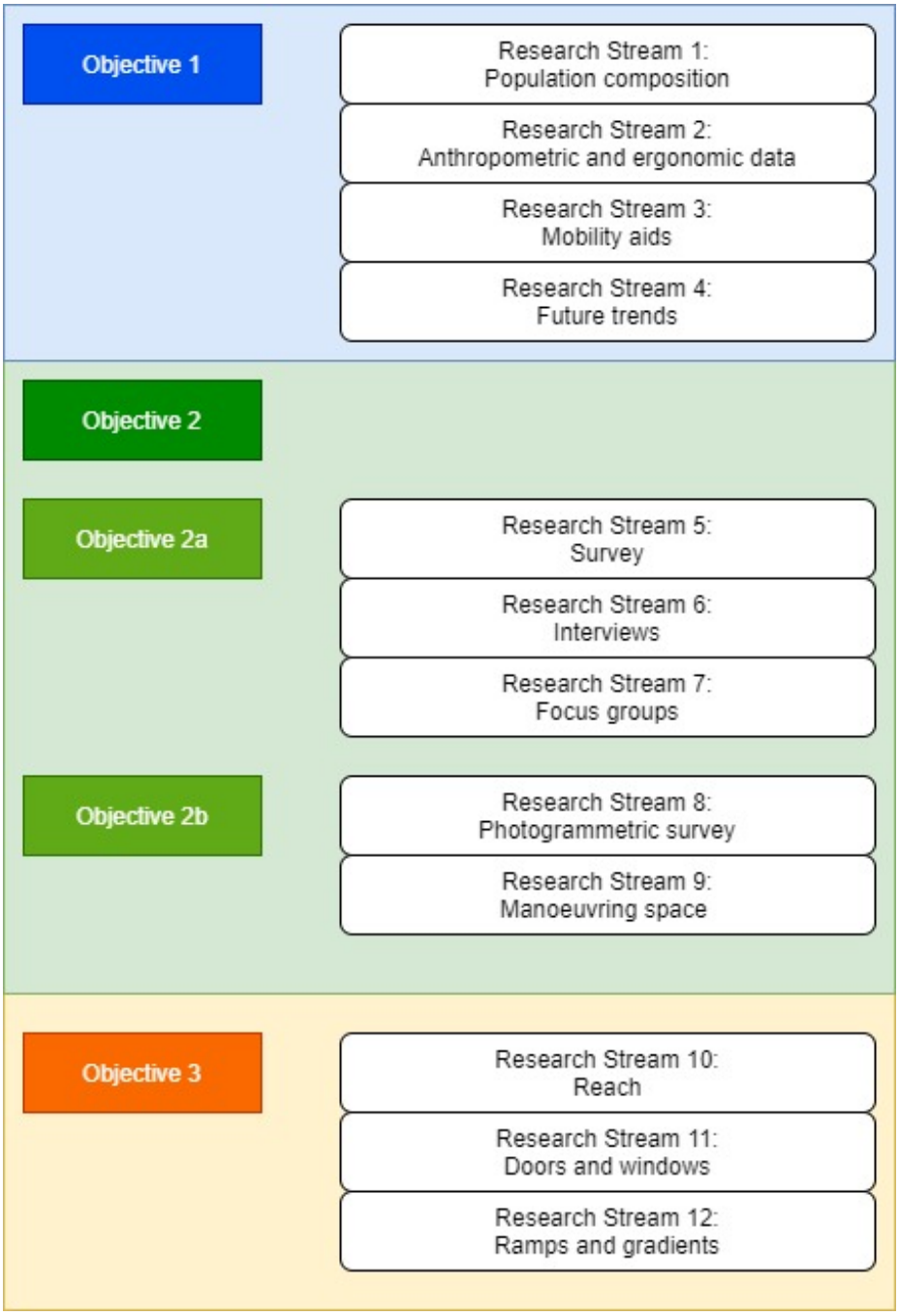


Figure 1. Programme of objectives and research streams.

2. Objective 1: Literature and data review

A thorough review of existing published literature and data was undertaken to understand what evidence and research exists regarding disability, mobility aid use, population demographics and anthropometric and ergonomic data.

The review included a wide range of literature and data sources, including data from the Office of National Statistics (ONS), NHS Digital data and General Practice Research Database and Quality and Outcomes Framework data, and published research from academic, government, NHS, private sector and third sector sources.

The search for literature and data, and the subsequent review, focused on four key Research Streams:

- The demographic composition of, and prevalence of disability and mobility aid use in, the population of England (see Section 3).
- The anthropometric and ergonomic data that current design guidance is based on, both in relation to mobility aid users and the general ambulant population (see Section 4).
- The use, type and classification of mobility aids (see Section 5).
- Future trends in demographics and disability that may be relevant to a future update to Approved Document M (Volumes 1 and 2) and Part M of the Building Regulations (see Section 6).

The review was important to establish the most current and available demographic and disability data for England, as well as identifying future trends in disability and mobility aid use, and the impact of this in relation to current standards and guidance for the built environment.

3. Research Stream 1: Population composition

The literature and data review aimed to understand both the current demographics of England and the prevalence of disability and mobility aid use in England.

To achieve this key demographic and disability categories were identified and the literature and data review used to determine both the estimated prevalence of the category as a percentage of the total population and the estimated prevalence range (where data varied across different sources) (see Section 3.1 for demographic data and Section 3.2 for disability data).

One research consideration was the possibility that the COVID-19 pandemic may have impacted demographic data in 2020. For this reason, data from 2019 and 2020 were both considered (where available) to see if there was a significant difference. Approximately 125,000 excess deaths due to all causes were registered in England and Wales between March 2020-2022[i], and there was a reduction in the birth rate in 2020 of approximately 25,000 when compared to 2019[ii]. As a result, the overall impact on the pandemic on proportional demographics was limited (<0.1% of the total population). Where COVID-19 is considered likely to have impacted on data, this is noted in the relevant section.

Section A.1 in Appendix A provides data tables that list the relevant sources and findings for each demographic group and disability group category, including sample sizes (where applicable) and a red / amber / green (RAG) rating for both data quality and availability.

3.1 Demographic categories

3.1.1 Age

Approximately one-fifth of the population of England is over 65, and one-fifth is under 18[2] (see Table 1). In total, roughly 40% of the population fall outside the 18-65 age range. This has implications for the built environment, as these age groups have different anthropometric and ergonomic characteristics compared to other age groups. Older people are also more likely to be disabled or have long-term health conditions.

For the review, data was broken down into the following categories: children under 5 years old, children aged 5-12 years old, and adolescents aged 13-18 years old. These age ranges were chosen as they represent meaningful differences in independence and the use of the built environment. The 13-18 years old age range is ergonomically significant as it is when sex difference between children begins to have anthropometric impact.

[2] Younger population demographics have major gaps with regards to disability prevalence and are often not broken down by age group.

Table 1. Estimated prevalence of different age groups as a percentage of the population in England.

Age	Lower range	Upper range
65 years old and over	16.34%	18.41%
80 years old and over	4.60%	4.95%
Under 18 years old	21.39%	21.39%
Under 5 years old	5.73%	6.26%
5-12 years old	9.02%	9.96%
13-18 years old	6.77%	7.37%

3.1.2 Sex and gender

The male and female split in the population is almost even with slightly more females recorded. This has implications for the built environment, as anthropometric and ergonomic characteristics will generally differ by sex.

Minimal data is available on gender identity with less than 1% currently reported as identifying as transgender or non-binary (see Table 2).

Table 2. Estimated prevalence of sex and gender as a percentage of the population in England.

Sex and gender	Lower range	Upper range
Male	48.96%	49.18%
Female	50.82%	51.04%
Transgender / non-binary	N/A	0.24% (UK)

3.1.3 Ethnic group

The prevalence of some disabilities and health conditions varies according to ethnicity; however a detailed breakdown of condition variation by ethnicity is outside the scope of this report, which looks at general prevalence only. Most of the population in England is White, followed by approximately one-tenth of the population Asian / Asian British (see Table 3).

Table 3. Estimated prevalence of different ethnic groups as a percentage of the population in England.

Ethnic group	Lower range	Upper range
White	84.24%	85.42%
Asian / Asian British	7.82%	8.28%
Black / African / Caribbean / Black British	3.48%	3.67%
Other ethnic group	1.03%	1.93%

3.1.4 Families and people caring for children

Caring for children will have implications for the built environment as specific facilities and space requirements are required to meet children's and parent / guardian needs.

Dependent children[3] make up approximately one-fifth of the population, with families including dependent children making up around one-tenth of the population (see Table 4).

However, caring for children is not a permanent feature of any one person but is situational (i.e. children do not always accompany their parent / guardian; number of children a person cares for at any one time may vary), there is also a lack of data providing a clear indication of the number of individuals who care for children in some capacity (e.g. family member, friend, nursery worker etc.) so demographic data (e.g. number of people with children) is unlikely to be the best method to inform the Building Regulations.

Table 4. Estimated prevalence of families and people caring for children as a percentage of the population in England.

Families and people caring for children	Lower range	Upper range
Dependent children	21.64%	No equivalent data
Families with dependent children	12.09%	12.29%
Families with non-dependent children[4]	4.46%	11.82%

[3] Dependent children are those living with their parent(s) and either (a) aged under 16, or (b) aged 16 to 18 in full-time education, excluding children aged 16 to 18 who have a spouse, partner or child living in the household.

[4] Non-dependent children are those living with their parent(s), and either (a) aged 19 or over, or (b) aged 16 to 18 who are not in full-time education or who have a spouse, partner or child living in the household. Non-dependent children are sometimes called adult children.

3.1.5 Language and communication

In the built environment, signage, wayfinding, communication and emergency communication often contain verbal or written information. All these features are key to creating accessible and inclusive spaces.

Approximately one-tenth of the population in England does not have English as their main language, approximately 20% of which either cannot speak English well or cannot speak English at all (see Table 5). Amongst all adults, just under 5% have a literacy proficiency level below Level 1[5]. This has implications for the built environment in terms of how information is provided (i.e. alternative formats: pictorial, audible, or tactile will be necessary).

Table 5. Estimated prevalence of communication and language as a percentage of the population in England.

Communication and language	Lower range	Upper range
Main language is not English	7.98% of total population	N/A
Main language is not English: cannot speak English well	1.39% of total population 17.45% of population whose main language is not English.	51.04%
Main language is not English: cannot speak English	0.26% of total population 3.29% of population whose main language in not English.	N/A
Adult literacy (literacy proficiency below Level 1)	3.3%	N/A
British Sign Language as main language	0.03%	N/A

3.2 Disability categories

Disability and / or health conditions are likely to impact on use of the built environment generally (e.g. the ability to use stairs comfortably; space required to accommodate mobility aids etc.) and in more specific ways (e.g. potential implications for travel distances and the need for rest in the built environment etc.).

However, figures for disability prevalence generally vary widely depending on how disability is defined. Research into the Labour Force Survey indicates that changes in the survey method and wording of questions have significant impact on results[iii]. Inclusion of the word ‘disability’, and specific reference to include mental health conditions and illness, can affect people’s likelihood of self-reporting.

[5] The International Survey of Adult Skills 2012 provides the following definition for literacy proficiency: Level 1 defined as ability to read brief texts on familiar topics to locate a single piece of specific information – e.g. to identify a telephone number in a short piece of text).

Additionally, the review of data identified two main data types: self-identification and data from health, welfare and social care systems. There are limitations to both types of data.

Self-identification in surveys does not tend to collect extensive information about disability, and often does not permit people to report multiple conditions. For example, a person may select that their main disability / condition is 'vision'. This does not indicate the degree or type of visual condition or allow them to report additional disabilities. Additionally, some people may not report themselves as having a disability or health condition e.g. if this does not significantly impact their life, or they have not received a formal diagnosis.

Data collected through health, welfare and social care systems is dependent on people using those services and data being recorded and reported accurately. For example, the NHS collects data about the number of people referred to psychological therapies. This does not necessarily indicate the number of people with mental health conditions, as not everyone will seek or receive psychological therapy.

Disabilities and health conditions may vary widely in presentation and degree from person to person and may also change over the course of an individual's life. Therefore, data collected at one point in time may not reflect future trends and needs with regards to the built environment.

Section 3.2.2 includes a review of demographic intersections that was undertaken to better understand the distribution of disability amongst different age groups.

3.2.1 Disability prevalence and categories

Between 20-40% (approximately) of the population in England are disabled or have a long-term health condition (see Table 6).

Table 6. Estimated prevalence of disability as a percentage of the total population in England.

Disability	Lower range	Upper range
Disability / long-term health condition (general)	17.6%	43.0%
Blue Badge[6] holders	4.2%	No equivalent data.

Figure 2 and Figure 3 show the estimated prevalence ranges of different disability categories and health conditions as a percentage of the total population in England.

[6] The Blue Badge scheme helps disabled people and/or people with health conditions to park closer to their destination, either as a passenger or driver in England. Some people may automatically qualify for a Blue Badge, other people will need to apply to their local authority.

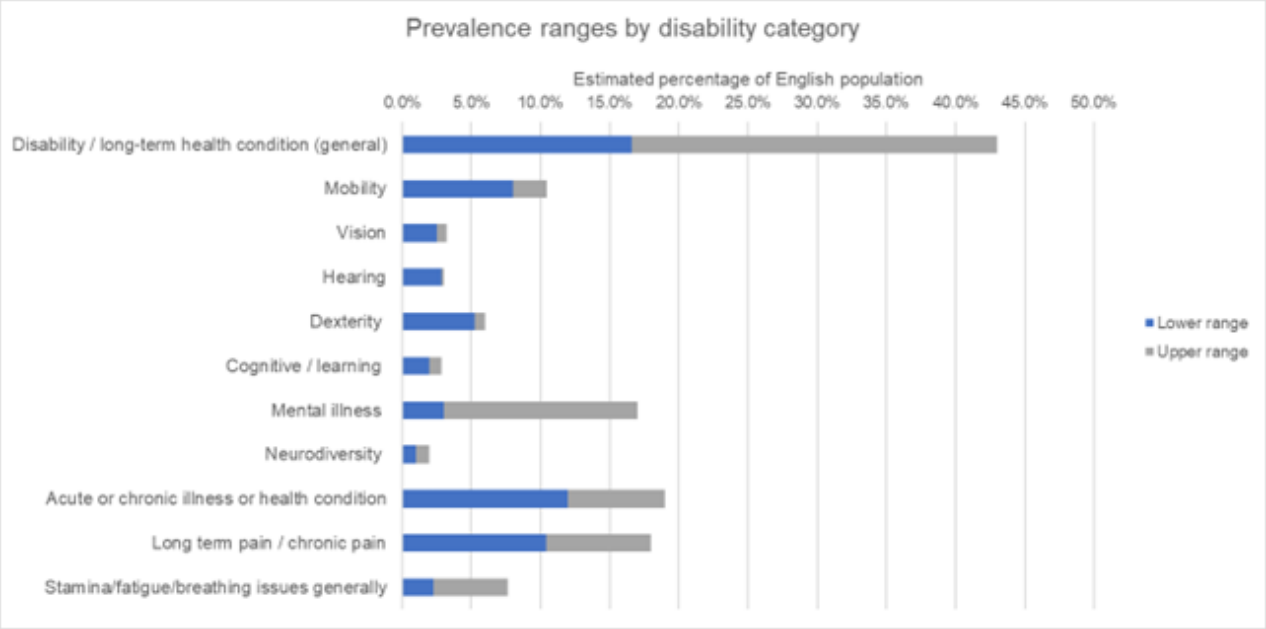


Figure 2. Estimated prevalence ranges of different disability categories as a percentage of the population in England.

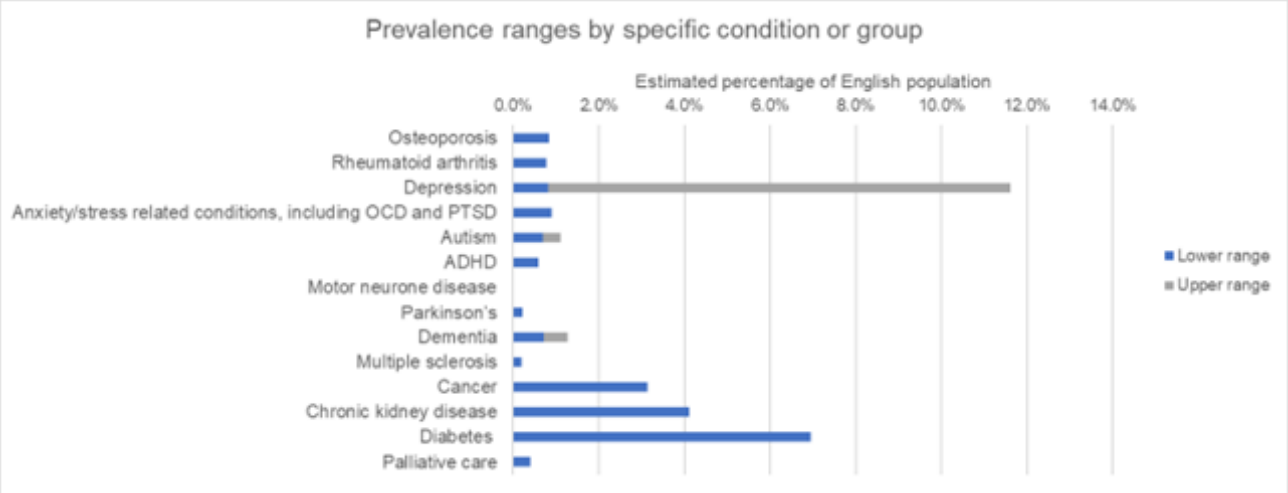


Figure 3. Estimated prevalence ranges of different health conditions as a percentage of the population in England.

The key findings include:

Mobility related disability

The estimated percentage range for mobility-related disabilities in England is 8-10.5%. The difference between the lower and upper range figures may be, in part, due to an increase in mobility-related disability over the 10-year period between the two surveys (Life Opportunities Survey, 2009/12 and Family Resources Survey, 2019/20) from which data was obtained.

The Health Survey for England 2013 collected information about mobility aid use by people over 65, indicating that approximately a quarter of older people (65 years and

older) use mobility aids of some kind, including wheeled and ambulant aids. See Section 5 for a more detailed analysis indicating the prevalence of mobility aid use in England that is likely to be indicative of mobility-related disability.

Sensory related disability (hearing and vision)

The estimated percentage range for sensory-related disabilities in England is between approximately 2-3% (for both hearing and vision).

There may be much wider proportions of the population who have some level of vision or hearing loss but who would not report this as a condition that impacts their life (e.g. not all people who wear non-prescription reading glasses would consider themselves to be partially sighted). This review has not considered data on widespread assistive technologies (such as glasses and hearing aids) that are available over the counter – this may require a major review of manufacturer and supplier data which is outside the scope of this report. Section 8.3.2 includes a review of data on other assistive technologies.

Dexterity related disability

The estimated percentage range for dexterity in England is between approximately 5-6%.

Self-reported dexterity issues may present differently for different people, impacting general strength or precise movement that may have particularly consequences in the built environment (e.g. using doors, switches and controls etc). Dexterity and its ergonomic impact has been further considered in Section 6.7.3.

Cognitive / learning disability

The estimated percentage range for cognitive / learning disabilities in England is between approximately 2-3%[7].

Collating accurate data on the number of people with learning disabilities is challenging because some of the most reliable data sources – such as the reporting of Special Educational Needs in schools – is focused on children. Figures cannot be simply extrapolated to the rest of the population due to the lower life expectancy of people with learning disabilities and the high rate of co-occurrence of disabilities and other health conditions. However, recorded administrative figures for people with learning disabilities fall by approximately 80% above school age[8] – it is not realistic that this is due to lower life expectancy only; instead, it is more likely that adults are less likely to use learning disability services.

[7] NHS Digital data and the Quality and Outcomes Framework data record people with learning disabilities who are on the clinical register at their local GP. These reported figures are significantly lower than those found through large-scale population surveys (i.e. the Family Resources Survey, 2019/20 and Life Opportunities Survey 2009/12), and lower than Public Health England estimates from 2015 which collate data from a range of sources including use of adult social care services and the results of epidemiological research. For this research, estimates that incorporate sources other than the clinical registers have been used as they are considered to be more representative of the current population.

[8] School leaving age may vary; administrative figures will generally be based on the actual population in the school, not a specific age group sample.

Mental health

Figures for the prevalence of mental health conditions vary widely. The estimated percentage range for mental health conditions in England is between 6-17% approximately.

Figures reported from NHS Digital data or from GP practices tend to record significantly lower rates, as data is based on referrals and diagnoses. Self-identification with mental health conditions in large-scale surveys is higher. The highest figures are reported from the Adult Psychiatric Morbidity Survey 2014, which identifies individuals who meet the criteria for a common mental health disorder. Specific figures for rates of anxiety-related conditions appear significantly lower as only NHS Digital data is available.

The COVID-19 pandemic may have impacted on mental health, depression, and anxiety/stress more generally. There is not yet centrally recorded data reflecting this on a wide scale, but the potential impact on prevalence should be considered.

Neurodiversity

National survey questions do not ask specifically about neurodiversity or neurodiverse conditions but generally do provide an opportunity for respondents to report a long-term condition or disability described as ‘social / behavioural’.

The estimated percentage range for neurodiversity in England is between approximately 1-2%.

Estimates for the prevalence of neurodiversity are typically significantly higher than reported figures in large-scale surveys. NHS statistical estimates have also been considered as the upper range for all categories – these figures include estimates of autism prevalence in people with learning disabilities. Autism prevalence in people with learning disabilities is higher than in the general population, but this population is not incorporated into Adult Psychiatric Morbidity surveys for autism.

Acute or chronic illness or health conditions

The estimated percentage range for acute or chronic illness or health conditions in England is between approximately 12-19%.

A significant disparity between sexes was reported by the Health Survey for England 1993-2018, with the lower range estimate indicating the percentage of males experiencing “acute sickness”[9] and the higher range estimate indicating the percentage for females.

The Quality and Outcomes Framework collects data on high-dependency and long-term conditions at a regional level, including cancer and diabetes, and people in palliative care. The total sum prevalence of these conditions is 14.59%, approximately in line with the reported range for chronic illness, although this does not account for possible co-occurrence of disabilities. The presentation of these conditions will vary over time and from person to person, and people may have different needs in the built environment accordingly.

The review also considered temporary illness / injury. Widespread data on the number of temporary injuries may be collected by GP practices; within the scope of this research

[9] The Health Survey for England defined “acute sickness” as: any illness or injury, including longstanding, that has caused participant to cut down on things they usually do in the past 2 weeks.

exercise it has not been possible to collate all data on temporary injuries due to the large quantity and inconsistency of reporting across different GP Practices. Due to the wide range of temporary illnesses and the different ways they may present, this is not considered to be a representative figure for use of the built environment. The review considered average figures for people with 'not fit for work' notes from GPs (estimated 0.62% in any one month). This data covered only people who are in work and able to obtain a 'not fit for work' note, therefore, this would disproportionately weight estimates against disabled and older people, who are less likely to be in employment[10] [iv].

Long-term pain / chronic pain

The estimated percentage range for long-term or chronic pain in England is between approximately 10-18%.

This category has been included in part because people experiencing pain-related conditions, particularly because of ageing, may not report their condition as a disability or illness. However, long-term or chronic pain is likely to impact on mobility, particularly ambulant disability, and use of the built environment generally (e.g. the ability to use stairs comfortably).

Stamina / fatigue / breathing issues

The estimated percentage range for stamina / fatigue / breathing issues in England is between approximately 2-8%.

Large-scale survey data on this topic does not clearly distinguish between fatigue issues and issues with breathing (which could include, for example, asthma) which may account for the disparity in reported prevalence.

This category is included as it has potential implications for travel distances and the need for rest in the built environment. For the purpose of accessibility in the built environment, self-reported experiences of fatigue may also be highly relevant as they may be indicative of a desire or need for rest / short travel distances, regardless of whether a clinical diagnosis is in place.

3.2.1.1 Pregnancy

Pregnancy is not a disability or health condition but was included because it impacts on an individual's anthropometric and ergonomic characteristics and their accessibility needs (e.g. the need for rest, or access to sanitary facilities).

The data available on the prevalence of pregnant people in England at any one time is limited and tends to be low in quality. Approximately 1.5% of the population is pregnant at some point each year (see Table 7).

[10] See ONS dataset: 'A08: Labour market status of disabled people', November 2021.

Table 7. Estimated prevalence ranges of pregnancy as a percentage of the population in England.

Category	Lower estimate	Upper estimate
Pregnancy carried to term	1.04%	1.14%
Pregnancy total	1.50%	N/A

3.2.1.2 Multiple, profound and complex disabilities

Large-scale demographic data surveying the number of people with multiple, profound and complex disabilities is not typically collected in national surveys or studies. However, significant research and population estimates have been carried out to investigate the need for Changing Places toilets in the past twenty years. Research results are not always directly comparable, as they are based on assumptions about specific demographic groups or disabilities / conditions that would mean a person would require Changing Places toilets.

Much of this research was undertaken outside the United Kingdom and is based on small sample sizes (see Table 8). This is further complicated as multiple disabilities and complex assistance needs are also found in care homes, hospices and end-of-life care facilities. While some research accounts for these populations; some research concentrates solely on profound multiple learning disabilities. Research indicates that profound multiple learning disabilities have an extremely high co-occurrence rate with mobility-related disability and the need for assistance, up to 98.7%[v].

From the literature and data review, estimates of the proportion of people with complex assistance needs in England are provided; however, these data points are projected estimates for the wider population, based on limited data sets.

Table 8. Demographic data - multiple, profound and complex disabilities.

Basis of estimate	Prevalence (number)	Prevalence (proportion)	Source	Year of research	Location
Estimate of UK population with needs in specific categories who may potentially require support, including Intellectual Disability, Physical Disability (e.g. Cerebral Palsy) and Older People[11].	223,798 – 230,252	0.36-0.37%	"Changing Places Toilets: Estimates of potential users". Prof. James Hogg, University of Dundee (commissioned by MENCAP).	2009	UK
Estimate of people (adults and children) with profound multiple learning disabilities in England (Based on 2008 data about prevalence rate in children and adults).	30,780	0.05%	"Estimating future numbers of adults with profound multiple learning disabilities in England". E. Emerson, (commissioned by Department of Health).	2008	England
Number of people with severe and profound intellectual disability within the catchment of an intellectual disability centre in Finland, extrapolated for the whole population.	-	0.13%	"Prevalence, aetiology and comorbidity of severe and profound intellectual disability in Finland". M Arvio et al.	2003	Finland

[11] Note, for accuracy, terminology within this table is taken from the research referenced and, therefore, does not necessarily align with the terminology used elsewhere in this report.

3.2.2 Demographic intersections

Section A.2 in Appendix A provides detailed data relating to the prevalence of disability amongst older people and children.

Disability and older people

In general, older people have a significantly higher prevalence in all disability categories except for neurodiverse conditions (including autism and attention deficit hyperactivity disorder (ADHD) (see Figure 4).

The prevalence of disability or long-term condition is estimated at almost half for people over 65 (from 46-48%), reaching an estimated 66% for people over 80. A quarter of people over 65 are estimated to use mobility aids of some kind.

Data shows the prevalence of autism and ADHD in older populations to be lower. This may be because autism and other neurodiverse conditions were not included in diagnosis or disease classification manuals until the 1970s/80s, and children were initially the focus of most diagnoses[vi,vii]. Children today are still more likely to be identified as neurodiverse, in part because many diagnoses, particularly for ADHD, are identified through school.

Data from GP practices across the UK indicates that the life expectancy for people with learning disabilities is significantly lower than for the general population. The median age at death for someone with profound learning disabilities is 40 years[viii]. As a result, the prevalence of learning disability in older demographics is significantly lower.

The prevalence of issues with balance, fatigue and breathing has not been compared here. Different data sources apply different measures to identify these issues (for example, some surveys consider only breathing) and they are therefore not directly comparable. Older people experience significantly higher rates of illness, which will impact on the ability to move without fatigue and hold standing positions.

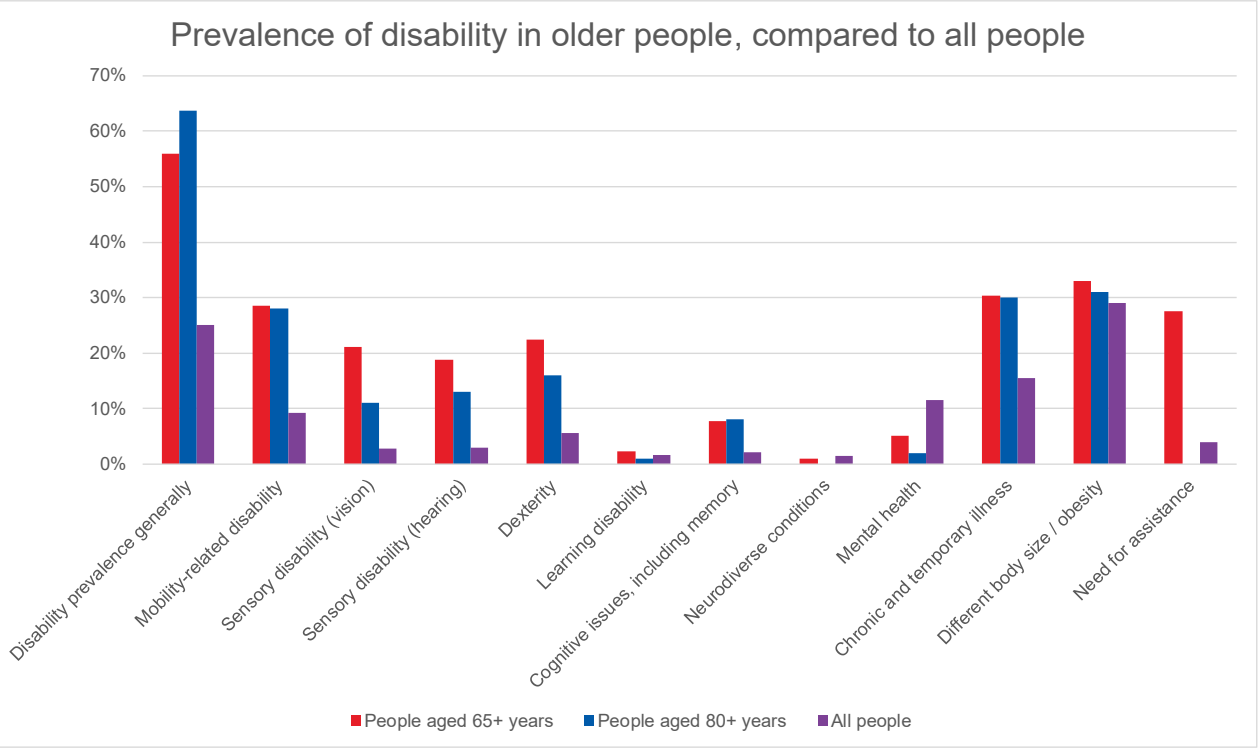


Figure 4. Prevalence of disability in older people compared to all people in England[12].

Children

Disability prevalence data for people under 18 years old is limited. A high proportion of national surveys used as data sources do not collect data from people under 18 or under 16 years of age.

Figure 5 shows the prevalence of disability in children generally as against the general population, as taken from the 2019/20 Family Resources Survey – data on disability intersection stratified by age range is not generally available.

A higher proportion of children are estimated to be neurodiverse. Figures for learning disability are also shown to be higher in children. This is likely to be both a result of higher prevalence and higher reporting rates in children (see Section 3.2.1).

[12] Note, the following: 1) due to negligible data, a value is not provided for people aged 80+ years for 'neurodiverse conditions'; 2) 'chronic and temporary illness' includes degenerative and progressive conditions; 3) due to limitations in the available data, 'different body size / obesity' uses data for people aged 75+ years for people aged 80+ years; 4) 'need for assistance' data is taken from the Health Survey for England 2018/19; due to the way the data is stratified an accurate prevalence percentage cannot be provided for people aged 80+ years, so no value is given in the graph.

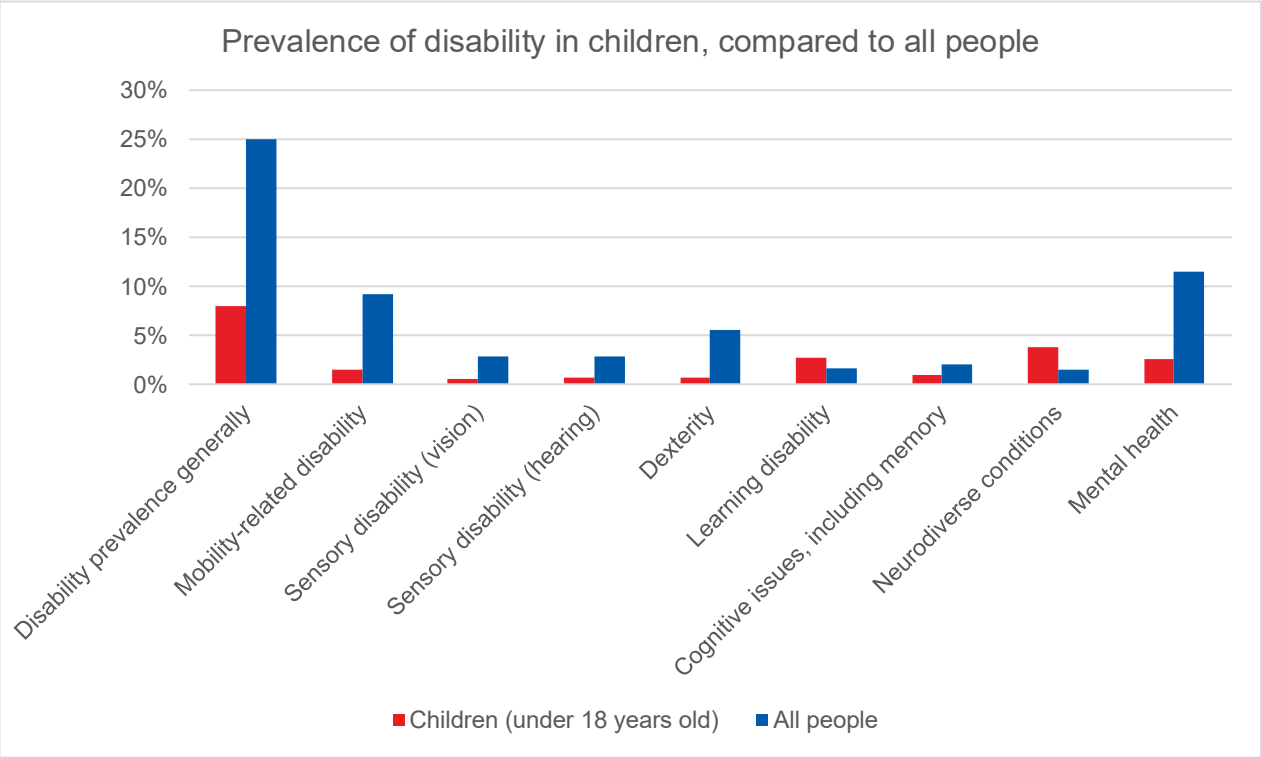


Figure 5. Prevalence of disability in children compared to all people in England.

3.2.3 Need for assistance

People who need assistance with daily tasks may live or visit places with other people, either informal or formal carers or assistants. This may impact on space requirements within enclosed spaces (rooms and lifts) and sanitary facilities, as well as the design of homes, communal facilities, workplaces and venues.

Large-scale surveys have been conducted which review proportions of older people who need assistance. Limited data is available for the population of England as a whole. Figures shown in Table 9 have been extrapolated from figures for the population aged 65 years and over against the proportion of people aged 65 years and over at the time of each study and do not incorporate need for assistance for people under 65.

Surveys (e.g. the Health Survey for England) tend to categorise all children under 16 years of age or in full-time education as ‘dependent’ and having ‘carers’, although this is unlikely to always translate to a need for physical assistance with carrying out tasks.

Table 9. Demographic data for England - need for assistance.

Demographic – need for assistance	Lower range	Upper range
People receiving care at least once a week	0.77% of total sample 7% of all people receiving care	3.75%
People requiring assistance with Activities of Daily Living (largely within the home)	4.62%	4.97%
People requiring assistance with Instrumental Activities of Daily Living (largely outside the home)	4.72%	4.78%

3.3 Summary and key findings

The aim of the literature and data review was to understand both the current demographics of England and the prevalence of disability and mobility aid use in England.

The key findings are:

- Approximately one-fifth of the population of England is over 65, and one-fifth is under 18. In total, roughly 40% of the population fall outside the 18-65 age range. This has implications for the built environment, as these demographic groups have different anthropometric and ergonomic characteristics. Older people are also more likely to be disabled or have long-term health conditions.
- More than 20% of the population report having a disability or long-term condition that impacts their life. This rises to as much as 65% in people over 65. This figure does not account for all people who may have access needs but not consider themselves to have a disability / long-term condition.
- Significant proportions of the population experience health conditions which may not be considered ‘disabilities’ but which will impact on use of the built environment. This includes sickness and illness (12-19%), fatigue (2.25-7.63%), and long-term pain (10.4-18%). Total figures could be between 24.65 – 44.3%, though it is more likely that there is significant overlap between these conditions.
- Estimates for the prevalence of disability generally, and the prevalence of specific disabilities and conditions, vary widely. Further research is recommended into the collection of disability data to identify the best questions and phrasing to gain accurate responses and to allow people to report multiple conditions.
- The review indicates that the rate of co-occurrence and multiple disabilities is high, but specific data in this area is extremely limited. Further research and the revision of current large-scale surveys is recommended to allow people to report multiple conditions.

4. Research Stream 2: Anthropometric and ergonomic data

The literature and data review aimed to identify relevant sources of anthropometric and ergonomic data, for disabled and non-disabled people.

To achieve this current anthropometric and ergonomic data for both disabled and non-disabled people, and for older and younger people was reviewed (see Section 4.1). The review covered a range of data sources, including data from the PeopleSize database[13].

Key sources for anthropometric / ergonomic data include:

- PeopleSize 2008 and 2020.
- AdultData, Older AdultData and ChildData 1995-2000.
- Department of Environment, Transport and the Regions research 1997-2001 (unpublished, reported in BS 8300 Annex E and Health Building Note 00-04)[ix].
- Department for Transport (DfT) - 'A survey of Occupied Wheelchairs and Scooters' (2005[14])[x].
- Department for Transport (DfT) and conducted by the Atkins-Jacobs Joint Venture - Reference Wheelchair Research Full report (2021)[xi].
- Department of Trade and Industry (DTI) - Specific anthropometric and strength data for people with dexterity disability (2002)[xii].
- Arjo Guide for Architects and Planners.

Section A.3 in Appendix A provides data tables that list the relevant sources and findings for the general population and disabled people, including comments on data availability.

4.1 Anthropometric data

General population

The most robust and recent data set for anthropometric data generally is PeopleSize 2020[15]. PeopleSize 2020 UK data is based on the Health Survey for England, derived averages from 2009-2018, to give a total sample size of 73,363. The sample is designed to be representative of the population living in private households[16] in England. PeopleSize

[13] PeopleSize is a large-scale anthropometric and ergonomic database that collates multiple data sources relating to human size and shape into a single resource. Since 1994, PeopleSize has been the anthropometric data sourced used by market leaders and is industry leading for ergonomic design.

[14] The study was published in 2006; however, the work reports the results of a survey conducted in 2005 and will be referred to as the 2005 study in this report.

[15] The PeopleSize method was validated with the 2008 dataset, against two 'gold standard' population surveys: the National Health and Nutrition Examination Survey (NHANES) conducted by the US Government, and the Health Survey for England conducted by the UK Government.

[16] 'Private households' are defined by the ONS as encompassing: "one person living alone, or a group of people (not necessarily related) living at the same address who share cooking facilities and share a living room, sitting room or dining area. A household can

data is adjusted to the most recent and authoritative international data sources, ranging from 1999-2018. All physical sizes are represented in this data set with the most current information.

Older and younger people

PeopleSize 2020 incorporates data for all age ranges including older and younger people.

As identified in Section 3.2.2 the prevalence of disability among older populations is high, exceeding 50% for people over 80 years old. This does not necessarily mean that anthropometric data on older people is therefore representative of older disabled people as well – disabled older people, particularly those with multiple and mobility-related disabilities, are often not included in anthropometric studies. However, studies into strength and dexterity have tended to focus on older populations as these groups are most likely to have dexterity-related disabilities and conditions.

The prevalence of disability in children is relatively lower than for other age groups. Anthropometric data for disabled children is scarce and this should be considered in relation to the built environment.

Mobility aid users

Height and weight data for occupied mobility aids has been extracted from previous research on mobility aids for the Department for Transport (DfT) research into occupied mobility aids (2005; 2021) and are included in Table 10 and Table 11.

Average figures for all adult chairs have been included here for comparative purposes only. Gaps in the data represented in the PeopleSize database are identified with N/A.

consist of a single family, more than one family or no families in the case of a group of unrelated people.". See ONS website www.ons.gov.uk for more information.

Table 10. Percentile height measurements.

Category	Height (mm, 5th percentile)		Height (mm, 50th percentile)		Height (mm, 95th percentile)	
	Males	Females	Males	Females	Males	Females
General population (18-64 years old)	1644	1517	1759	1623	1874	1729
Older people (65+ years old)	1593	1472	1708	1570	1822	1668
Older people (85+ years old)	1553	1444	1665	1538	1777	1632
Younger people (0-4 years old)	851	828	N/A	N/A	1230	1219
Younger people (5-12 years old)	1033	1018	N/A	N/A	1665	1662
Younger people (13-18 years old)	1463	1482	N/A	N/A	1878	1744
Occupied wheelchair (all wheelchair types)	1141 (2005 report)		1291 (2005 report)		1516 (2021 report)	

Table 11. Percentile weight measurements.

Category	Weight (kg, 5th percentile)		Weight (kg, 50th percentile)		Weight (kg, 95th percentile)	
	Males	Females	Males	Females	Males	Females
General population (18-64 years old)	63	51	81	67	108	96
Older people (65+ years old)	61	51	76	66	100	92
Older people (85+ years old)	57	47	66	60	78	85
Younger people (0-4 years old)	11	11	N/A	N/A	28	28
Younger people (5-12 years old)	15	15	N/A	N/A	65	69
Younger people (13-18 years old)	36	39	N/A	N/A	73	83
Occupied wheelchair (all wheelchair types)	67.0		118.4		230.2	

4.1.1 Ergonomic data

The space and reach requirements for specific ergonomic use cases can be derived from data on reach range, strength and dexterity. Research into these areas reports a wide variety of ergonomic use cases.

For increased clarity, one key ergonomic measure has been taken to represent each category and to give an indication of ergonomic variation across demographic groups. Data in Table 12 has been taken from PeopleSize 2008, which covers a range of sources, with strength data taken from small studies only. Gaps in the data represented in the PeopleSize database are identified with N/A.

- Reach range: abduction – acromion to knuckle[17]
- Dexterity: wrist twist data – ridged knob[18]

[17] Refers to arm length from shoulder to knuckle, a dimension used to derive reach range

[18] Measures force applied to twist a particular type of knob used in ergonomic studies, which is easily grippable by people with limited dexterity

Table 12. Ergonomic data.

Category	Reach range (mm, 50th percentile)		Strength (N, mean)		Dexterity (Nm, mean)	
	Males	Females	Males	Females	Males	Females
General population (18-64 years old)	668	608	613.00	N/A	4.66	3.35
Older people (65+ years old)	655	599	N/A	N/A	4.37	2.84
Older people (80+ years old)	643	598	N/A	N/A	N/A	2.64
Younger people (0-4 years old)	413	397	225.90	218.84	0.86	0.56
Younger people (5-12 years old)	N/A	N/A	482.20	435.17	2.60	1.98
Younger people (13-18 years old)	N/A	N/A	N/A	N/A	4.00	2.89

4.1.2 Space requirements for disabled people

Anthropometric and ergonomic data relating to disabled people was conducted to inform development of BS 8300 guidance between 1997-2001. This research has been incorporated into design guidance in BS 8300 and Health Building Notes (including 00-04 Circulation and communication spaces). Table 13 sets out key dimensions identified from this research.

Table 13. Space requirements for disabled people.

Category	Comfortable reach range (height) (mm)	Eye height (mm)	Width requirements for circulation (mm)
Ambulant person	750-1500	1423 (woman) 1750 (man)	600
Independent wheelchair user	650-1000 (height) 665-1060 (side)	1320	900
Wheelchair user with attendant	N/A	1320	900
Person with walking frame	N/A	N/A	900 (minimum), 1000 (recommended)
Person with crutches	N/A	N/A	1200
Blind / partially sighted person using stick	N/A	N/A	1000-1200
Person with walking frame and assistant	N/A	N/A	1200 (minimum), 1400 (recommended)

Wheelchair and mobility aid users

The most up-to-date anthropometric study on the occupied mobility aids is the 2005 research commissioned by the Department for Transport, which tested approximately 1350 adult and child mobility aids and occupants.

Mean figures for the height, length, width and weight of child and adult devices have been summarised in Table 14.

Table 14. Dimensions of occupied mobility aids (mean figures for all types of mobility aids).

Category	Height	Length	Width	Weight
Adult device (all types)	1287 mm	1113 mm	612 mm	130.7 kg
Child device (all types)	1125 mm	978 mm	546 mm	66.5 kg

Ambulant disabled people

The available data does not consider the reach range, eye height and height specifically for ambulant disabled people using walking aids.

Dexterity / strength data for disabled people

Dexterity and strength studies have been conducted on people with dexterity- and strength-related disabilities. The best data source in this area is the Department for Trade and Industry research / report 2002, which conducted detailed studies on a sample size of 300 disabled and 100 non-disabled people.

Other conditions / health conditions

All studies that report condition groups are often of limited use. Access to adequate population sizes is hindered by the recruitment and selection process for research. In addition, many of the conditions have wide-ranging symptoms and presentations that the population coverage would need to be very high to gain validity.

4.2 Key anthropometric dimensions

Key anthropometric dimensions relating to body size and potential space requirements from PeopleSize 2020 are provided in Table 15 and Table 16.

Table 15. Key anthropometric dimensions from PeopleSize 2020 - larger dimensions.

Dimension type	Relevant demographic group	Percentiles			
		85th	90th	95th	99th
Total body breadth	Male 18-64 years old	599 mm	607 mm	622 mm	650 mm
Hip breadth	Female 18-64 years old	406 mm	415 mm	429 mm	457 mm
Hip height (greatest)	Male 18-64 years old	975 mm	988 mm	1007 mm	1043 mm

Table 16. Key anthropometric dimensions from PeopleSize 2020 - smaller dimensions.

Dimension type	Relevant demographic group	Percentiles			
		15th	10th	5th	1st
Hip height (smallest)	Female 65+ years old	775 mm	764 mm	748 mm	719 mm

The data from PeopleSize 2020 has been compared against the 5th and 95th percentile measurements in PeopleSize 1998 to look for significant changes and trends over time (see Appendix A for data comparison).

Key findings include:

- Significant increase in weight for males and females, with male weight increasing by around 7-10 kg and female weight increasing by around 7-11 kg for adults aged 18-64 years old.
- Increase in total body breadth and depth for females. Decrease in total body breadth and depth for males.
- Hip breadth has decreased for both males and females.
- Slight increase in height for both males and females.

Given the trend towards rising obesity rates in the UK[xiii], it may be expected that total body breadth and hip breadth would have increased for all demographic groups. This trend is reflected in changes in weight from 1998 to 2020, but not across all adult data. This could be because:

- Data for older populations (65+ years old) in relation to specific total body breadth is not available, and these age groups may have a greater breadth / be more impacted by changes in body size generally.
- The increase in weight is accounted for by increase in height.
- Sizes in the upper range (95th – 100th percentile) are increasing at a disproportionate rate to the overall mean and 50th percentile. This cannot be proved using the current data but should be considered in the ongoing research

4.3 Summary and key findings

The aim of the literature and data review was to identify relevant sources of anthropometric and ergonomic data, for disabled and non-disabled people.

Key findings include:

- Anthropometric data is available that differentiates between sex and age groups.
- Comparison of this data revealed expected results: older and younger people tend to be shorter, smaller, less physically strong and lighter than the general population. Men

tend to be heavier and taller than women at all age ranges outside childhood. This review of data is not revelatory but can be used for comparison against current assumptions in Building Regulations about ergonomic and anthropometric requirements.

- More significantly, the review found that large-scale anthropometric data studies have historically not incorporated disabled people or mobility aid users. Studies conducted specifically on disabled people are not always evaluated against general population data and may use different methods and sample sizes that make it difficult to draw meaningful comparisons.
- As a result, anthropometric or physical measurements of disabled people with substantial sample sizes are not available for review in all categories. It is recommended that future rolling studies consider the size and space requirements of disabled people to ensure that building standards can be based on data that is genuinely representative of current populations. The disability prevalence review identified that as much as 10% of the population could have a mobility-related disability – including this and other groups in data collection could have a major impact on anthropometric assumptions generally.

Anthropometric data also varies with sex difference and difference in ethnic group. However, these variations have not been reviewed in detail under the scope of this research.

5. Research Stream 3: Mobility aids

The literature and data review aimed to identify the prevalence, different types, and distribution of wheeled mobility equipment and walking aids in England.

For the purposes of this review, the term wheeled mobility equipment (WME) includes but is not limited to wheelchairs, power wheelchairs, standing wheelchairs and scooters. The term walking aids (WA) includes but is not limited to walking sticks, crutches, walking frames, and wheeled walking frames. These terms were chosen as they reflect the UK and international trends identified within the current published literature (LaPlante and Kaye 2010), (Gooberman-Hill and Ebrahim 2007).

Table 17. Categories and type of mobility aid equipment reviewed.

Walking aids	Wheeled mobility aids
• Sticks • Crutches (including gutter crutches) • Non-wheeled walking frames • Wheeled walking frames (2-4 wheels) • Combination frames (with seat)	• Manual attendant propelled • Powered attendant controlled • Self-propelled • Self-propelled with power unit • Powered • Standing • All terrain
Scooters	**Hoists**
• All types and classes	• Passive / full body • Mechanical standing • Non-mechanical standing

5.1 Prevalence of mobility aid use (general)

Table 18 shows the prevalence of mobility aid use (general) in England from review of the available data.

Table 18. Demographic data - prevalence of mobility aid use.

Demographic – prevalence of mobility aid use (general)	Lower range	Upper range	Lower range source	Upper range source
Registered with NHS Wheelchair services	1.1%	1.8%	NHS National Wheelchair Data Collection Quarterly results (Oct-Dec 2019)	NHS estimate for total number of wheelchair users in UK (2019)
Proportion of population who use a mobility aid and are 65+ years old	4.5%[19]	No equivalent data	Health Survey for England Adult Social Care 2013	N/A

5.2 Prevalence of mobility aid use (by type)

The review identified that there is no single centralised data source that provides data about how many people are using particular types of term wheeled mobility equipment (WME) or walking aids (WA) in England.

There are several complexities to collecting or reviewing this information, including:

- Statutory and private provision
  - The NHS provides a large number of WME to patients each year. However, there are also many private purchases of WME. There is no single source that combines both statutory and private provision, nor is there a robust source for either statutory or private provision in isolation.
- Commercially sensitive data
  - Sales information from manufacturers or distributors could be collected to determine the most popular WME types – however, this data is often considered commercially sensitive, and retailers will generally not provide it for research purposes. Our research obtained data from one manufacturer – this manufacturer principally supplies powered wheelchairs, so the data is not representative of all manufacturers or distributors.
- Multiple aids
  - Many WME users will use and own more than one different type of WME, often in combination with other WA. A survey conducted as part of this research (see Section 8) indicated that, of the 114 WME users who responded, 27% used more than one different type of WME (e.g. powered, self-propelled, attendant-propelled)

[19] This is calculated according to the percentage of people who are aged over 65, and the percentage of this group who use a mobility aid, according to thew 2013 Health Survey for England and ONS Mid-year population estimates for 2013.

and 57% used at least one WA in addition to their WME (e.g. crutches or a walking frame).

Previous surveys of occupied WME have used convenience sampling and identified significant changes in the observed prevalence of different WME and WA over time.

5.3 Literature review

This section summarises the findings of a literature review conducted by TOTS into the use of WME and WA in England (see Section A.4 in Appendix A for list of studies reviewed).

Data is included from a range of studies that include different WME and WA users, from those with spinal cord injuries (see Haisma et al. 2006) to those experiencing 'frailty' in older age (see Gale, Cooper, and Sayer, 2015). Where possible UK based data and statistics are included, but where this data is absent from the literature, appropriate international studies are also included, such as the United States (US) review on step-climbing power wheelchairs (see Sundaram et al., 2017).

5.3.1 Literature review findings

Wheeled mobility aids

In paper 3, Fitzgerald and Kelleher[xiv] identify both the technological advancement of ultralight wheelchair frames and the freedoms that WME offers users, exploring how manual wheelchairs are adaptable to suit a range of user needs and environments. They describe how WME provides the means for those who use them to move independently and to be active members of society, participating in home, work, or school and leisure activities.

The same benefits can be ascribed to the users of powered wheelchairs and scooters, with paper 4[xv] identifying that access to powered mobility impacts positively on areas of independence, quality of life, mobility, and engagement. The prevalence of these different types of WME in England or internationally is not identified in any of the literature found within this review, but according to NHS England (2021), there are 1.2 million wheelchair users (manual and powered) in the UK.

In paper 4, Fomiatti et al.[xvi] also identify that scooters are usually designed for people with limited walking ability and substantial difficulty with body control, while powered wheelchairs are generally devices of choice for people with higher levels of limitation. In paper 9, Mortenson and Kim[xvii] describe a scoping review undertaken to identify research related to scooter use. In this review, they note that mobility scooters are typically used to facilitate community mobility, tend to be less adaptable to individual needs, and are more affordable than powered wheelchairs. However, they also found evidence that there were many barriers to scooter use, including the risk of accidents and injury due to physical barriers in the built environment.

Ambulant mobility aids

Within this review, much of the data for England or the UK on WA prevalence pertained to that of the older population. Whilst representing a large proportion of users, this does not give a complete picture of the current use in the wider adult population. For example, the English Longitudinal Study of Ageing (ELSA)[xviii] examined only participants who took part

in the Health Survey for England and who were aged over 50 years, and so this data can only be generalised to the older UK population and does not represent the data of younger adults. Despite this, the papers included in this review provide some understanding of the proportional distribution of different types of WA in this population.

In paper 5, Gale, Cooper, and Sayer[xix] examine data collected from the ELSA that relates to 'frailty' and disability, exploring participants' experiences of barriers to everyday activities and use of assistive devices including walking aids. The English longitudinal study of ageing (ELSA) is a population-based sample of older men and women. Gale, Cooper, and Sayer[xx] found that the most used WA among those with mobility requirements was a walking stick, used by 63% of those who were deemed to be 'frail' and 20% who were not 'frail'[20][xxi]. They found the use of powered mobility aids to represent only a small proportion of respondents (exact percentage data not provided in the study).

Few previous studies appear to have directly examined the use of WA in the UK, but these findings appear to be supported by a survey of people aged 72-83 years old by Gooberman-Hill et al.[xxii], which found that walking sticks were the most frequent WA used.

This is also corroborated by data collected by the leading market researcher Statista (2021) for a survey about mobility aid use that found 25% of female respondents and 17% of male respondents, over 65 years of age, reported using a walking stick, significantly more than any other form of WA.

The range of challenges posed to working-age adults with mobility requirements in the UK is highlighted by Souza et al. (2010) in paper 12, where they describe the findings of a systematic review of mobility-related assistive technology and multiple sclerosis (MS). The paper identifies that 80% of people with MS experience gait problems and that a range of WA such as walking sticks, crutches, and walkers are commonly used by this group.

The review also highlights that people with MS with mobility requirements often require assistance to mobilise both in and out of their homes and the appropriate choice of mobility aid, whether WA or WME is often crucial to an individual's quality of life, with significant impact upon their careers, family life and mental health.

Use of anthropometric data and ergonomic data to inform Building Regulations

The standards used to ensure accessibility for people who use WA and WME are based on research in anthropometry: the measurements of body sizes and physical abilities (Steinfield 2010). These standards typically include dimensions for clear floor areas, manoeuvring clearances, seat and knee clearance heights, as well as some reference dimensions on WME sizes. Very little of the research identified within the review by Steinfield (2010) explored the specific anthropometric measurements of WA or WME - either internationally or in the UK - although several sought to discuss the things that are currently included, and should be included, to get a more accurate understanding of the space needed by WA and WME users.

In paper 1, Barros and Soares (2012) indicate that understanding the variation in functional characteristics of the sample population included was key to establishing the range and complexity of anthropometric data. They identified that although the dimensions of wheelchairs varied by brand and model, the anthropometric data was also influenced by

[20] Frailty in this case was defined according to the Fried criteria, which uses four criteria - weight loss, exhaustion, low physical activity, slowness and weakness – to define frailty.

the functional capabilities of the users – for example, reach data will vary not only because of the size of chair, but due to whether and how the person in the chair is able to perform the reaching action.

In paper 3, Fitzgerald and Kelleher (2005) highlight the importance of considering that WME are typically individually tailored to fit the user. They describe how customized seating systems provide a better fit and maximise seated posture and pelvic stability, reducing the risk of repetitive strain injuries commonly associated with some WME. It is also important to acknowledge that how people sit in and use WME is also influenced by their specific disability or condition, and this also varies according to the ability (e.g. muscle strength, respiratory function) of the individual user (Haisma et al. 2006) and their individualised set up of their WME, all of which contributes to a range of possible anthropometric data for users of WME.

It has long been understood that the paucity of accurate anthropometric data on WME users can limit projects to create suitable environments (Marcio 1998). In paper 8, Molenbroek and de Bruin (2006) discuss the challenges of designing accessible built environments using Dutch accessibility standards, providing the example of designing an accessible restroom. They discuss the use of common anthropometric standards for WME and their users and the flaws and inconsistencies with these, including the limited one-dimensional body space information and the difficulties associated with a tendency to design for the mean, often excluding those smaller or taller than this.

Space requirements for accommodating WME and WA and their users in the built environment are key components of standards for accessible design (Steinfeld 2010). Similar difficulties were identified in paper 11, where Steinfeld et al (2010) found that the size described in both US and UK accessibility standards were also closer to the mean values found in anthropometric research studies and were not sufficient to accommodate a large enough proportion of WME users.

Molenbroek and De Bruin (2006) advocate for a different approach, focussing on a design for all or inclusive design. They argue that "this does not mean that a designer has to design for all 6 billion people on earth, but it means that throughout the design process he or she must take into consideration that as few people as possible are excluded." Inclusive design or design for all is also known across the international literature as design for the widest possible audience.

6. Research Stream 4: Future trends

The literature and data review aimed to identify trends in demographics and disability prevalence over the next 5, 10, and 20 years.

This was achieved through a review of existing population projections from a variety of sources, including ONS National Population Projections[21], to identify demographic trends and the prevalence of disabilities and long-term health conditions in England. Projections were also combined with qualitative insights to give an idea of the population breakdown over the next 5, 10 and 20 years.

For each demographic and disability category, the following was identified:

- The estimated prevalence of the category as a percentage of the total population.
- The population increase from the baseline over 5, 10 and 20 years.
- A brief gap analysis and assessment of the quality of available data.

Data availability has not been assessed in this section as projections are based on estimates rather than existing data. Where sufficient data is not available to inform a projection, the projection has not been included.

Key sources for demographic data include:

- ONS population projections
- University of Leeds Ethpop database
- The Migration Observatory - Centre on Migration, Policy and Society, University of Oxford
- UN world population projections.

Key sources for the prevalence of various disabilities include:

- Historic data from the Family Resource Survey
- Sight Loss Data Tool - Royal National Institute of Blind People (RNIB)
- Care Policy and Evaluation Centre – The London School of Economics and Political Science (LSE)
- Health Profile for England (2017-2021) – Public Health England

6.1 Age

The population of England is aging (see Table 19). Population projections from the ONS indicate that at present, there are more people under 16 than over 65 in England. By 2027, this will have changed.

[21] Where population projections were unavailable, historic data has been evaluated to look for significant trends.

Projecting out 20 years indicates that the gap between older and younger populations will continue to widen, with approximately 22% of the population aged over 65 by 2042.

Life expectancy at birth in 2042 is expected to have increased by approximately 2 years from current rates for men and women. Female life expectancy will be 85 years and male life expectancy will be 82 years[xxiii].

On average, people aged over 65 spend around half of their later years with life-limiting health conditions or disability. Therefore, the projected increase in people aged over 65 will have a significant effect on mobility rates, disability prevalence and habits of the general population.

The projected increase in the older population will likely lead to increased strains on hospitals and caring facilities. With a large portion of care currently being delivered by family and friends or private caring facilities, if the trend of reduced funding continues, these groups will be required to manage more of the caring responsibilities[xxiv].

Table 19. Future trends data for England – age.

Age band[xxv]	5 years (2027) (projected % of total population)	10 years (2032) (projected % of total population)	20 years (2042) (projected % of total population)
0-16 years olds	17.8	16.5	15.9
65+ year olds	18.4	19.6	21.9

6.2 Migration

The net inward migration is expected to remain at over 150,000 for the next 5-, 10- and 20-years (see Table 20). The ONS projection does not attempt to predict the impact of political circumstances such as Brexit. Net international migration makes up 73% of the projected population growth, therefore the unpredictability of political circumstances has a large impact on the projection[xxvi].

While Brexit is expected to slow down migration rates, there are other unpredictable trends that could increase migration rates. For example, the number of people being displaced due to climate change will likely increase; as climate change is disproportionally effecting parts of Africa and Central and Southwest Asia, this may lead to a movement of people to areas with less severe risk, including Europe[xxvii].

Table 20. Future trends data for England - migration.

Net inward migration[xxviii]	5 years (2027) (000s of people)	10 years (2032) (000s of people)	20 years (2042) (000s of people)
Net inward migration	168	169	170

6.3 Sex and gender

The sex distribution in England is expected to remain constant with a slight increase in the number of males bringing the value closer to a 50/50 male / female split (see Table 21).

Despite there being limited data around transgender and non-binary populations, the Government Equalities Office LGBT survey found that 67% of transgender respondents said they avoided being open about gender identity for fear of a negative reaction from others[xxix]. As awareness increases in the general population people may be more open about gender identity which could lead to an increase in the recorded transgender and non-binary populations.

The 2021 Census included a question on gender identity which may provide a clear source for the number of transgender and non-binary people in England. This data has not yet been published (provisional release date of Jan 2023).

Table 21. Future trends data for England - sex and gender.

Sex distribution[xxx]	5 years (2027) (% of population)	10 years (2032) (% of population)	20 years (2042) (% of population)
Male	49.59	49.64	49.75
Female	50.41	50.36	50.25

6.4 Ethnicity, religion and faith

The University of Leeds have projected the ethnic population of England to 2050, considering the ethnic differences in fertility, mortality and internal and international migration. The projection was last updated in 2018 and employs two separate models – one model incorporates the anticipated impact of Brexit on migration rates and has been referenced in this report.

The projection sees a reduction in white British and white Irish in the UK by 2051 and an increase in the proportion of all other ethnicities (see Table 22).

Table 22. Future trends data for England - ethnicity.

Ethnic group[xxxi]	30 years (2051) (% change from current population)
White British	-19.6
White Irish	-0.4
White other	+7.4
Mixed groups	+3.1
Asian groups	+4.8
Black groups	+2.0
Chinese[22]	No data for current prevalence, but population expected to triple in size.
Other	No data for current prevalence, but population expected to increase in size by 6 times.

A report by the Pew Research Center has projected religious distribution down to country level[xxxii]. The UK Christian and Jewish population is expected to shrink by 2050 with many people moving towards the unaffiliated (see Table 23).

Excluding the unaffiliated, the Muslim population sees the largest population growth. The increase in Muslims, Hindus, Buddhist, Folk and other religions is attributed to increased migration rates, high fertility rates and younger populations in some groups and religious affiliation switching.

[22] Note, accuracy of ethnicity data may be impacted by both groupings chosen by researchers and self-reporting of respondents.

Table 23. Future trends data for the UK – religion and faith.

Religious affiliation[xxxiii]	30 years (2051) (% of population)	30 years (2051) (% change from current population)
Christian	45.4	-18.9
Muslim	11.3	+6.5
Unaffiliated	38.9	+11.1
Hindu	2.0	+0.6
Buddhist	0.9	+0.5
Folk	0.3	+0.2
Jewish	0.3	-0.2
Other	0.8	+0.1

6.5 Lifestyle and social circumstance

Household structures are changing in England. The Families and Households in the UK: 2020 bulletin by the ONS showed that average household size has remained fairly constant over the past two decades[xxxiv]. The two main groups that have been increasing are the number of people living alone - increasing by 4.0% - and the number of multifamily households. However, these remain a small proportion of the total population.

The number of couples living without children is expected to increase, linked to declining fertility rates and increasing life expectancy.

6.6 Obesity

Obesity has many associated risks that can impact the population. It can reduce life expectancy and play a factor in a range of chronic diseases, including cardiovascular disease, Type 2 diabetes, cancer, respiratory disease and mental health[xxxv].

Historical data, looking at the prevalence of severe obesity among adults in England, shows an increasing trend over the past 26 years. Severe obesity in women is 1-2% more prevalent than in men, with the difference between the two increasing in recent years.

The most comprehensive report on future projections of obesity in England was produced by the Government Office for Science in “Tackling Obesities: Future of Choices”, published in 2007[xxxvi]. This report indicates that by 2050 60% of males and 50% of females could be obese.

In recent years there has been an indication that the government will make further interventions to curb obesity. The government-commissioned National Food Strategy

recommends a sugar and salt tax to encourage manufactures to reformulate their products, the revenue could then be used to subsidise fresh fruit and vegetables to low-income families. Government policies such as these are unpredictable in outcome but may have an impact on the future obesity demographic.

6.7 Disability prevalence

Table 24 shows the sources and measures reviewed for this report to identify future trends in disability in England and the UK.

Table 24. Future trends data sources - disability.

Item	Source / measure
Disability	Projection from 10 years historic Family Resources Survey data
Mobility	Projection from 10 years historic Family Resources Survey data
Vision	Projection of sight loss and blindness, RNIB Data Tool
Hearing	Projection of hearing loss, Action on Hearing Loss

6.7.1 Disability and Mobility

Historic data from 2008-2020, obtained as part of the Family Resources Survey, shows:

- The number of people reporting a disability (of any kind) increasing over time from 10.9 million in 2008 to 14.1 million in 2020.
- The number of people with of mobility related disabilities remains relatively constant, fluctuating between a low of 6.5 million in 2013/14 and a high of 7.1 million in 2016/17. The trend appears to show a gradual increase over time, though this is not consistent year-on-year.

6.7.2 Sensory disability

A report produced by Deloitte for the Royal National Institute of Blind People (RNIB) assessed the economic impact of sight loss and blindness in the UK[xxxvii]. The projections do not account for improved treatment or policy changes that could affect the prevalence of sight loss and blindness. By 2040 the proportion of the population who are blind or partially sighted is expected to increase by 1.5% in males and 2.1% in females.

The charity Action on Hearing Loss anticipate that by 2035, 15.6 million people will be experiencing hearing loss[xxxviii]. This is heavily linked with the ageing population but is also affected by loud music and work noise.

6.7.3 Dexterity

This review looked to establish quantitative projections for dexterity issues generally, osteoporosis and rheumatoid arthritis, however, there is little data available on projected figures over the next 5, 10 and 20 years.

As shown in Section 3.2.2, dexterity related disabilities are more prevalent in older people than the general population, therefore, as a result of the ageing population we are likely to see an increase in dexterity related disabilities.

Dexterity related disabilities have been tracked as part of the Family Resources Survey. Since 2012/13, the survey has found that dexterity related disabilities have slightly increased by only 0.05%.

6.7.4 Learning disability

There is limited data containing future projections of people with learning disabilities over the next 5, 10 and 20 years. The Family Resources Survey shows learning disabilities to be rising since data started to be collected, increasing by 0.65% since 2012/13.

As indicated in Section 3.2.1, life expectancy for people with learning disabilities is lower than for the general population. A confidential inquiry reported in the NHS QOF Quality Improvement domain 2020/21, indicated that 42% of deaths for people with learning disabilities are premature[xxxix]. This is due to a high rate of co-occurrence of disabilities and other health conditions and illnesses. As a result, trends in the prevalence of learning disability are more likely to be led by advances in medical, health and social care than by demographic shifts in ageing. The proportion of people seeking social care for learning disabilities is higher in children (who are in contact via schools and colleges) than it is for older adults.

Research to understand more about the complexities of learning disabilities and co-occurrence with other health conditions would help to both address health inequities that impact people with learning disabilities and build a better projection of how widespread learning disabilities will be in the future.

Increasing awareness of the needs and capabilities of people with learning disabilities at all ages may also result in changes to the way they use the built environment. For example, higher employment rates may lead to increased independent travel use and occupancy of commercial and workspace.

6.7.5 Neurodiversity

Neurodiverse conditions have followed a similar trajectory to learning difficulties since 2012/13 according to the Family Resources Survey. Since the data started to be collected in its current format, neurodiverse conditions have risen by 0.69%, which could be related to greater awareness and higher diagnosis rates, or an increase in the actual prevalence.

Projections on neurodiverse conditions are not readily available however there has been a rise in positive press about the value of a neurodiverse work force. For example, GCHQ (Government Communications Headquarters) actively promotes itself as a neurodiverse employer, citing the benefits neurodiverse conditions can have on skills such as problem solving[xl]. These attitude shifts may result in wider general awareness and acceptance of neurodiversity, and resultant increase in reporting of these conditions where data is collected.

6.7.6 Chronic health conditions and other health conditions

Table 25 shows the sources and measures reviewed for this report to identify future trends in chronic health conditions and other health conditions in England and the UK.

An all-encompassing projection for illness, including chronic and temporary illness in England is not currently available. However, when particular illnesses are specified, it becomes easier to obtain projection values.

As the population of England ages, we can expect the levels of illness to rise.

Rates of diabetes and cancer are set to rise in tandem with the ageing population, and with general trends in health. Projections from Public Health England and Cancer Research UK indicate that by 2035, we can expect to see 1,000,000 cases of diabetes and 150,000 cases of cancer beyond current levels. The ability to accommodate people with chronic illness into the built environment will form a large part of adapting to make places accessible for older people moving forward.

Temporary illness and injury are difficult to provide projections for. In the long term, it seems likely that COVID-19 may, like seasonal flu, become an illness that affects some people each year. Data is not yet available on how this will impact general rates of sickness moving forwards.

Parkinson's prevalence is closely linked with an ageing population. Parkinson's UK has used prevalence data and 2015 ONS population projections to calculate the expected increase in Parkinson's in the UK over the next 5, 10 and 20 years. This projection doesn't include other influences such as smoking rates or life expectancy.

London School of Economics (LSE) have projected the number of older people with dementia across the UK. Like the Parkinson's UK report, this uses the 2015 ONS population projections, however it also considers the future changing prevalence as provided by the population ageing and care simulation.

Table 25. Future trends data sources – chronic health conditions and other health conditions.

Items	Source / measure
Parkinson's disease	Parkinson's UK projection from 2015 ONS data.
Dementia	London School of Economics projection from 2015 ONS data.
Diabetes	Public Health England projections.
Cancer	Cancer Research UK projections.

6.7.7 Mental health

There is limited current information available projecting the future prevalence of mental illness. As the population grows, if the current prevalence remains the same, by 2030 there will be 2 million adults and 100,000 more children and young people with mental health conditions than in 2013[xli].

There are several factors that could affect the prevalence rates over the next 5, 10 and 20 years.

- The COVID-19 pandemic has led to a rise in unemployment. Office for Budget Responsibility (OBR) show the UK unemployment rate reaching 6.5% by the end of 2021, this results in an additional 0.9 million people in unemployment.
- Analysis done by The Health Foundation anticipates that there could be an additional 200,000 people living with poor mental health as a result of the pandemic[xlii].

With social media use continuing to grow in the UK it is expected that this will continue to impact mental health cases. The negative impacts of social media are often publicised with heavy use appearing to contribute to a variety of mental health issues. Social media has also provided a space for people to discuss and share experiences. In the future it is possible that digital mental health services could use this to provide more support for individuals with mental illness[xliii].

Mental illness is the fastest growing disability from the data collected by the Family Resource Survey; it has risen by 3.16% since 2012/2013, much larger than neurodiverse conditions (the second fastest growing disability). Since 2012 there has been a rising awareness of mental health issues in the general population which could be associated with the increase in prevalence.

6.7.8 Stamina, fatigue, and breathing

This category refers to general issues with balance, fatigue, stamina or breathing which may impact on an individual's movement speed, ability to move over distance, and need for seating / rest in the built environment. A wide variety of conditions, disabilities and environmental factors (e.g. temperature and humidity) may impact on this.

Data-driven projections related to balance, fatigue and holding standing positions are not available. In addition, data on the prevalence of balance, fatigue and breathing cannot be directly compared for older populations and the general population.

As a result, it is not possible to generate a projection for these conditions based on changes in population composition. However, correlation of these issues with general physical health would suggest that older people are more likely to experience fatigue and balance issues. As a result, it is expected that their prevalence will increase due to an increase in the ageing population.

6.7.9 Impact of COVID-19

The COVID-19 pandemic during 2020-2021 had a disproportionate impact on disabled people, older people, and those designated 'extremely critical vulnerable' by government and healthcare policy[xliv]. The pandemic has impacted both our ability to collect data on disability and health conditions and had a material impact on particular demographic groups. Many of these can be expected to have a lasting effect over the next 5, 10 and 20 years.

During the COVID-19 pandemic, a UK 'stay-at-home' lockdown announced in March 2020 meant many office-based workers had to switch to home working. The fast-paced reaction meant that most were unprepared for home working, lacking suitable furniture and equipment. The consequence of this is currently unquantified, however, the lack of a suitable working environment can be expected to have physical and mental impacts. In addition to mental health and wellbeing, the ergonomic impact of at-home working is not yet understood.

As of 6th of June 2021, 385,000 people in the UK are reporting 'long COVID', still experiencing symptomatic effects despite having had COVID-19 over one year prior, with many reporting difficulties undertaking daily activities. The side effects of long COVID vary from person to person, and include fatigue, shortness of breath, muscle ache and difficulty concentrating. The future effect of long COVID remains uncertain although it is likely to remain a concern.

As mentioned in Section 3.2.1, COVID-19 has had a significant effect on people suffering with mental health as well as increasing new mental health diagnosis. Isolations and lockdowns have caused an increase in loneliness among the population. Having to cope with the extra stress of lockdowns has led to a spike in mental health problems, effecting unemployed people and young people in particular.

As we learn to live with COVID-19 future health data collection will provide a clearer indication on its impacts within the whole population.

6.8 Future trends

Demographics undergo continual change. The population of the UK is ageing and it is projected to continue to age; the Office for National Statistics (ONS) projects that by 2039 over one in five people in England will be aged 65 years and over (see Table 19). Immigration (see Table 20) and fertility rates are shifting and are impacted by multiple political, economic and cultural drivers.

Financial and labour markets, family structures and health regulation will likely be transformed by changing demands for services from this population. 'Retirement age' is already being redefined, as able workers remain at jobs longer or embark on alternative careers and State Pension age changes. The population will require and expect mobility solutions, medical innovations and care systems on a significant scale.

As well as the quantitative changes detailed, qualitative shifts and technical innovation will likely have a significant impact on future trends.

Most currently available healthcare resources are spent on reactive services, rather than preventative primary healthcare. Growing in importance is Primary healthcare; a proactive approach to health, which includes an engagement with all factors contributing to individual wellness: environment, genetics, social setting, behavioural factors such as diet and lifestyle, and access to public healthcare. Doctors, patients, and health care organisations are all becoming familiar with a new generation of online and mobile technologies which are fundamentally changing the way health care works.

Bionics is a nascent interdisciplinary science that integrates mechanical and electronic elements with biological organisms. The convergence of advanced materials with customisable, low-cost manufacturing techniques has prompted new generations of bionic technologies to increasingly be able to repair and enhance the human body. 3D printing is being extensively leveraged by the prosthetics market to reduce prototyping costs and provide a personalised fit.

Researchers have developed functioning prototypes of artificial organs that can replace a spleen, pancreas or lungs; an artificial heart has United States Food and Drug Administration (FDA) approval for use in patients.

Advances in technology and the changes of future healthcare systems have the potential to improve the quality of life for the entire population, particularly benefiting individuals living with chronic illness.

There is a strong correlation between health and future economic growth. While many of the statistical projections show a significant increase in disability (see Section 6.7) and, consequently, the need for assistance and sensory aids, we should not underestimate the innovative ways we can help all to continue to live a healthy life, irrespective of ability.

6.9 Summary and key findings

The aim of the literature and data review was to identify trends in demographics and disability prevalence over the next 5, 10, and 20 years.

The key findings include:

- The population is ageing. By 2039, over 65s are expected to account for 23.7% of the population, an increase of 5.3% on current levels.
- Older people have a higher prevalence of disabilities and long-term health conditions, so the current prevalence of disability is likely to increase by a similar margin. This will have significant implications for the design of the built environment.
- Change and growth in the general population of England will likely largely be driven by inward migration. The rate of migration in the future, and the impact this will have on the population can be unpredictable and impacted by political, economic and cultural change.
- Existing projections for the future prevalence of disabilities and long-term illness are typically based on assumptions about the ageing population. There is a lack of future projections that consider other factors, such as the rise in obesity and the fall in cigarette smoking.
- Increasing awareness and acceptance of some disabilities and conditions, particularly mental health and neurodiversity, mean that data is likely to show an increase in these conditions over time.
- COVID-19 will be a significant driver of demographic and social trends over at least the next 5-year period.

Future trends: 5 years

The 5-year scale is expected to largely be impacted by COVID-19. It is hard to predict how long we will need to live with COVID-19 but the main implications of this - likely increased mental health issues, the health impact of long COVID and any habitual changes - are likely to be present in the short term. England is expected to continue to increase in population size and population age.

Future trends: 10 years

Over the next 10 years it is expected that the population growth will slow down. As the ‘baby boomer’ generation becomes older, fertility and mortality rates will begin to equalise. Net immigration is expected to be the main driver of the growing population; however, projections highlight the variable nature of this due to political, social and economic changes. As a result of an ageing population there will likely be an increase in prevalence

of age-related disabilities and illness, in turn, putting pressure on hospitals and formal / informal care infrastructure.

Future trends: 20 years

By 2041, the trend of an ageing population is expected to persist, highlighting this as a key driver over the 20 years, impacting healthcare and mobility.

There will likely be an ethnicity, race and religious shift, with an expected rise in Black, Asian and mixed-ethnicity groups in the UK. The religiously unaffiliated population will also likely increase in the UK as people move away from Christianity and other religions. The UK Muslim population is expected to increase along with other smaller religions like Buddhism and Hinduism.

If the trend of rising obesity continues, mobility issues and fatigue may become more prevalent, however, it is possible that through government intervention the current trajectory could be altered, as happened with smoking after it was banned from enclosed public spaces in 2007.

Future trends: beyond 20 years

The scope of this research is limited to a 5, 10 and 20 year projections. Considering demographics and disability prevalence in relation to impact on the built environment may require further research addressing longer time periods.

Buildings may expect to be refurbished after a 25-year period, and building fabric is typically expected to last approximately 60 years. To genuinely futureproof our built spaces, we may need to look much further into the future. Longer-term trends, including climate change and its impact on the physical environment and on migration, will likely also have an impact on future generations who will be living in the places we build today.

7. Objective 2a: Qualitative research

A qualitative research study was undertaken to collect qualitative data on the views and experiences of disabled people and people with long-term health conditions in using non-residential environments and their private dwellings.

The qualitative research focused on three key Research Streams:

- A survey to gather the views and experiences of disabled people and people with long-term health conditions in using non-residential environments in England (see Section 8).
- Structured interviews to gather the views and experiences of disabled people and people with long-term health conditions in using their private dwellings (see Section 9).
- Targeted focus groups to gain in-depth insight into the views and experiences of using the built environment by specific groups of disabled people and people with long-term health conditions (see Section 10).

The research was important to understand the common barriers and helpful features of the built environment that impact on accessibility and the everyday activities and experience of disabled people and people with long-term health conditions in England.

8. Research Stream 5: Non-residential survey

The qualitative survey aimed to understand the views and experiences of a wide range of disabled people and people with long-term health conditions about environments other than their private dwellings in England.

To achieve this an online survey was created - user-tested and approved by the TSG and DLUHC - then distributed by Arup and DLUHC via several public channels, including social media networks and direct email to representative groups and organisations working with and / or on behalf of disabled people and / or their families.

Figure 6 shows the survey structure. Demographic questions were informed by the findings from Objective 1. Focus categories for the barriers and helpful features[23] questions (e.g. circulation, sanitary facilities etc.) was informed by Approved Document M (Volume 2), BS 8300 Parts 1 and 2 and best practice guidance for access and inclusive design.

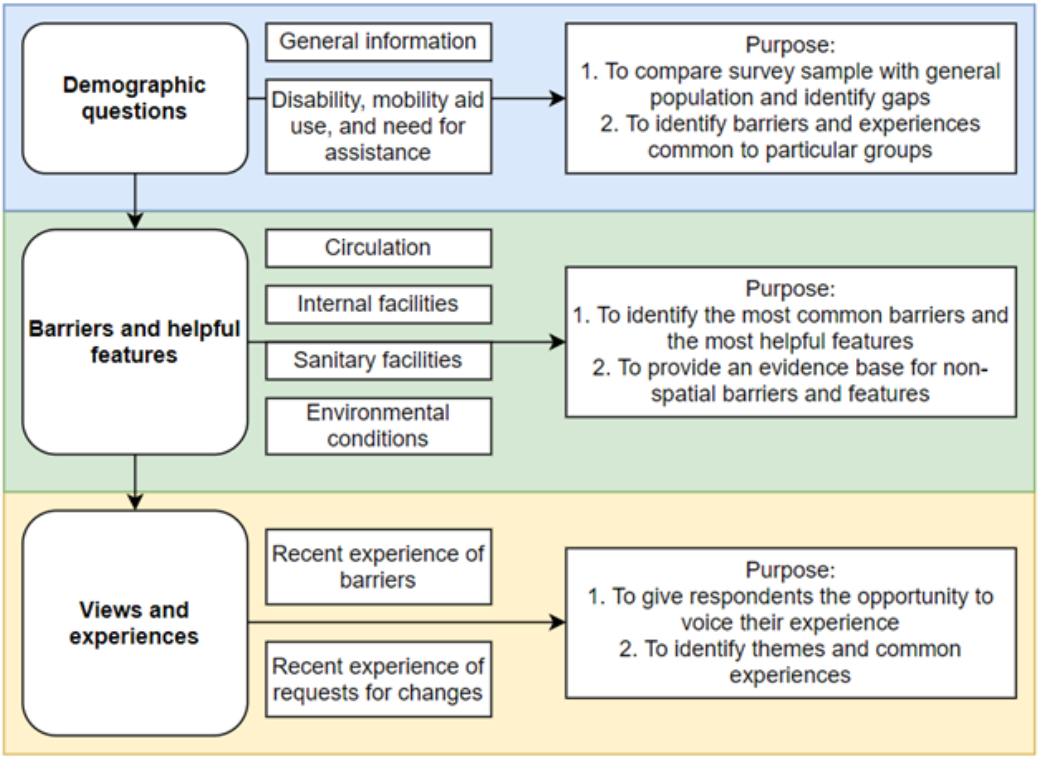


Figure 6. Survey structure for the non-residential survey.

The survey was open for 2 months between August 2021 and October 2021.

279 people completed the survey. Responses cut across disability and health condition categories and across a wide range of demographic groups. Respondents used a huge

[23] Barriers are defined as a feature of the built environment that limits or prevents access and / or make activities difficult or uncomfortable. Helpful features are defined as a feature of the built environment that helps or improves access and/or make activities easy or comfortable.

variety of mobility aids and assistive devices and ranged from people requiring no assistance in the built environment through to people with multiple live-in carers.

See Section B.1 in Appendix B for the survey questions and structure.

8.1 Demographics

All demographic questions were optional, to allow respondents to only provide information they felt comfortable sharing. Where no response was provided:

- The respondent was included in the overall assessment of results, but not in specific demographic analyses.
- Absence of response was not judged to indicate 'no', 'not applicable' or 'other'. Instead, analysis of each question was made only against the subgroup who responded to the question.

Demographic data from respondents was compared against the demographic data for England collected for Research Stream 1 (see Section 17) to identify any significant discrepancies between the data sets. Possible reasons for any discrepancies, and the potential impact of the discrepancy on the research findings, was considered as part of data analysis.

Of the 279 survey responses:

- There were a significantly higher proportion of female respondents than are present in the general population in England - 63% were female, 25% were male and 12% did not answer. 3% of respondents indicated they were transgender or non-binary. While previous data collection conducted on representative sample sizes indicates a disparity between the reported prevalence of disability and acute illness between men and women[24], the disparity is not by such a significant margin.
- People aged 18-64 were generally over-represented in the survey results, with other age groups slightly under-represented. Of respondents who provided their age, 69% were between 18-64 years old, 12% under 18 years old and 13% over 64 years old.
- For ease of data comparison, the same categories used in the 2011 Census was used to understand ethnic group distribution of survey respondents. White, Mixed / Multiple ethnic group, and Other ethnic groups were overrepresented in the survey response. Black and Asian ethnic groups were underrepresented. 87% of respondents were White, 2% were Asian / Asian British, 1% were Black[25], 6% were Mixed / Multiple ethnicity and 2% were Other. Response from different ethnic groups was monitored throughout the survey distribution, and targeted distribution was made to organisations and groups specifically working with racialised[26] disabled people. However, this did not fully address the representational gaps in survey completion rates.

[24] See Section 3.2.1.

[25] Includes Black / African / Caribbean / Black British

[26] Racialised groups are those who experience the simultaneous effects of race and gender. This term has been used above 'people of colour', which attempts to tame one's racial identity (see Shoneye, 2020, "As a black woman, I hate the term 'people of colour'"), and 'BAME or BME people', which homogenises all ethnic minorities and is not widely understood (see Mistlin, 2021, "So the term BAME has had its day. But what should replace it?").

Data gaps were identified for the oldest and youngest age groups, male response, and specific ethnic groups. These have been taken into consideration in data analysis.

8.2 Physical characteristics

Information on the following physical characteristics was collected from respondents to allow for further stratifying of responses:

- Pregnancy: 1% were pregnant, consistent with the Objective 1 estimate of 1.04-1.50% in the population of England.
- Larger body size / obesity: 18% reported a larger body size / obesity which is lower than the Objective 1 research estimate of 29% in the population of England. This could be due to a reluctance by respondents to self-report a larger body size, as national estimates are based on health data.
- Left-handed: 14% were left-handed, which is slightly higher than typical estimates of 10% of the population[xlv].
- Temporary injury: 4% had a temporary injury. The Objective 1 research found little reliable data for the rate of temporary injury or illness in general populations, so the survey findings were not comparable to the population of England.

8.3 Disabilities and health conditions

The survey received responses from people with a broad spectrum of disabilities, health conditions, and additional needs. To facilitate analysis and to avoid overly small sample sizes, the categories used in the survey have been grouped into broader overarching categories (see Section B.2 in Appendix B for the category groupings)[27].

Figure 7 shows the percentage of respondents who reported a disability or health condition by disability categories.

Around 10% of survey respondents did not report in any specific category (the question was optional) – these included older mobility aid users who may not have any specific health condition, for example, or people who reported barriers but chose not to respond to specific demographic questions.

Most respondents (49%) reported ‘Other chronic or long-term health conditions’ – this included long-term illnesses, digestive issues, and heart conditions – followed by a mobility-related disability or condition (48%).

[27] Many disabilities and health conditions are complex and cannot be simply categorised as ‘mobility’, ‘dexterity’ etc. To account for this, survey data has been analysed from several different angles, including: whether respondents reported using a mobility aid; and, whether respondents reported facing issues with particular areas of the built environment (e.g. operating controls, which could indicate dexterity issues).

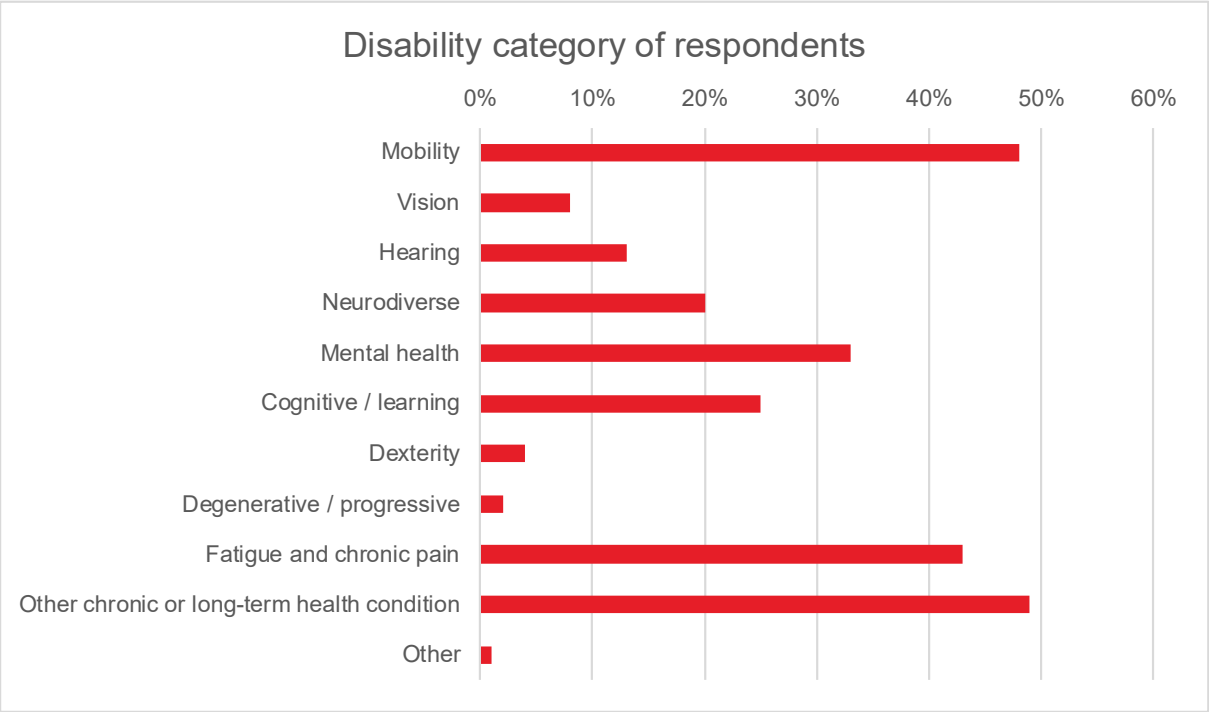


Figure 7. Disability category of respondents.

8.3.1 Co-occurrence of disabilities

The survey identified a high rate of co-occurrence of disabilities across respondents[28].

Based on the disability categories used for this research, 87% of respondents fell into one or more categories (excluding 'Other' responses), and 64% into two or more categories (see Figure 8).

- 73% of all survey respondents reported more than one specific condition or disability. Some participants reported 19 or 20 separate conditions.
- 64% of respondents reported conditions or disabilities in more than one category. 11% of respondents reported in more than 5 categories.
- On average, the category with the highest rate of co-occurrence was mental health. Respondents with mental health conditions on average fell into 1.7 categories.
- The lowest rates of co-occurrence were vision, hearing and degenerative / progressive conditions, with an average of 1 category for each respondent.

[28] Co-occurrence has been defined in two ways in the survey analysis: 1) proportion of respondents reporting more than one specific disability or condition – for example, multiple sclerosis and partial vision, and 2) proportion of respondents reporting a disability or condition in more than one category – for example, mobility and vision.

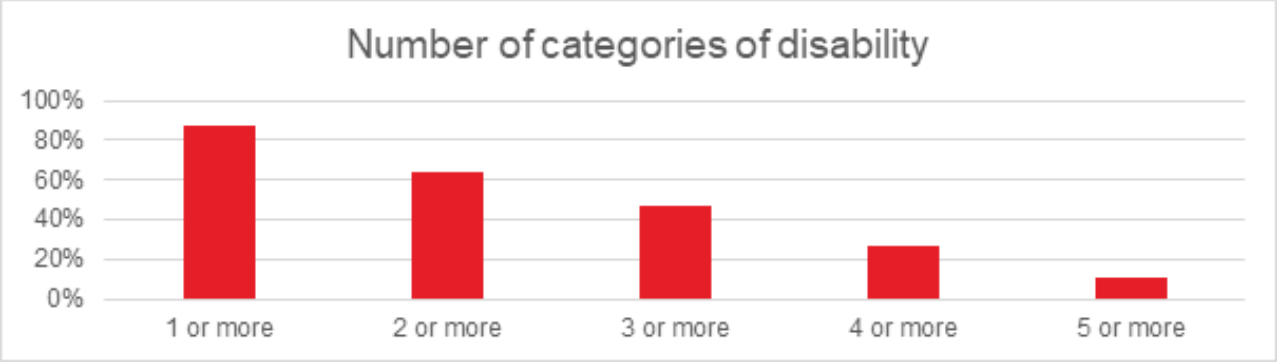


Figure 8. Number of categories of disability reported by survey respondents.

8.3.2 Mobility aids, assistive technologies, and assistive devices

Approximately 66% of survey respondents reported using a mobility aid or assistive device. 55% of all respondents reported using a wheelchair.

45% of all respondents reported using more than one mobility aid. 57% of wheelchair users reported using an ambulant mobility aid. This indicates that mobility aid use is difficult to generalise and will vary by individual.

Figure 9 shows the number of respondents reporting in each mobility aid category[29].

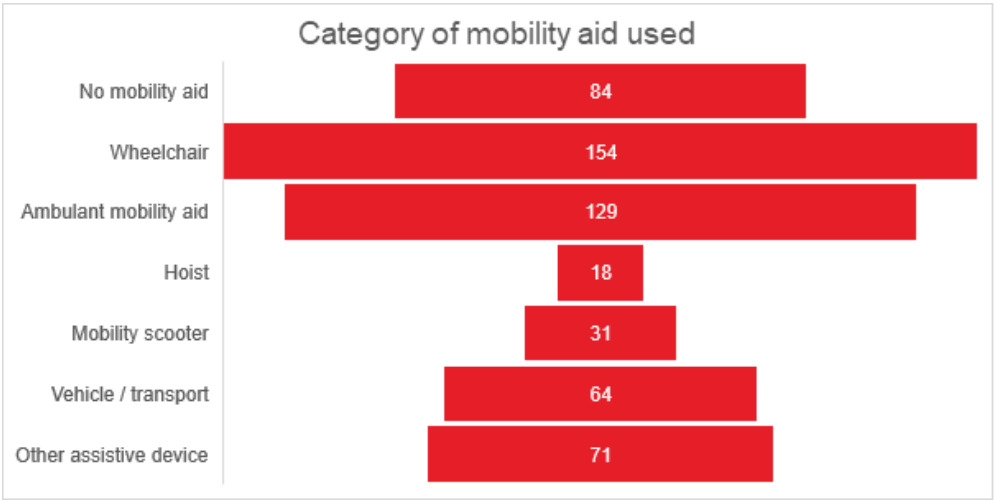


Figure 9. Number of respondents reporting in each mobility aid category.

Respondents were also surveyed to identify the use of assistive technologies (see Figure 10). The most common assistive technologies reported were mobile phone and smart home device[30].The actual use rate of each item of assistive technology may also vary by individual.

[29] The survey collected more granular data on specific mobility aids used by respondents; however, to facilitate analysis and to avoid overly small sample sizes, these were grouped into categories for the purpose of general analysis.

[30] Note, responses will likely have depended on respondents considering their mobile phone or smart home device as an 'assistive technology'. For example, the dexterity group were most likely to report using a mobile phone as an assistive device, despite the older age demographic of this group. It is unlikely that this older group are more likely to own mobile phones, as typically older populations have less mobile phone use (e.g. see Ofcom 'Adults' media use and attitudes' report, published 2017).

The findings for users of assistive technology by disability group were largely as expected – for example, people in the hearing group were far more likely to use a hearing aid (75%) and speech-to-text (25%) and people in the vision group were more likely to use vision-related technologies such as a screen reader (18%).

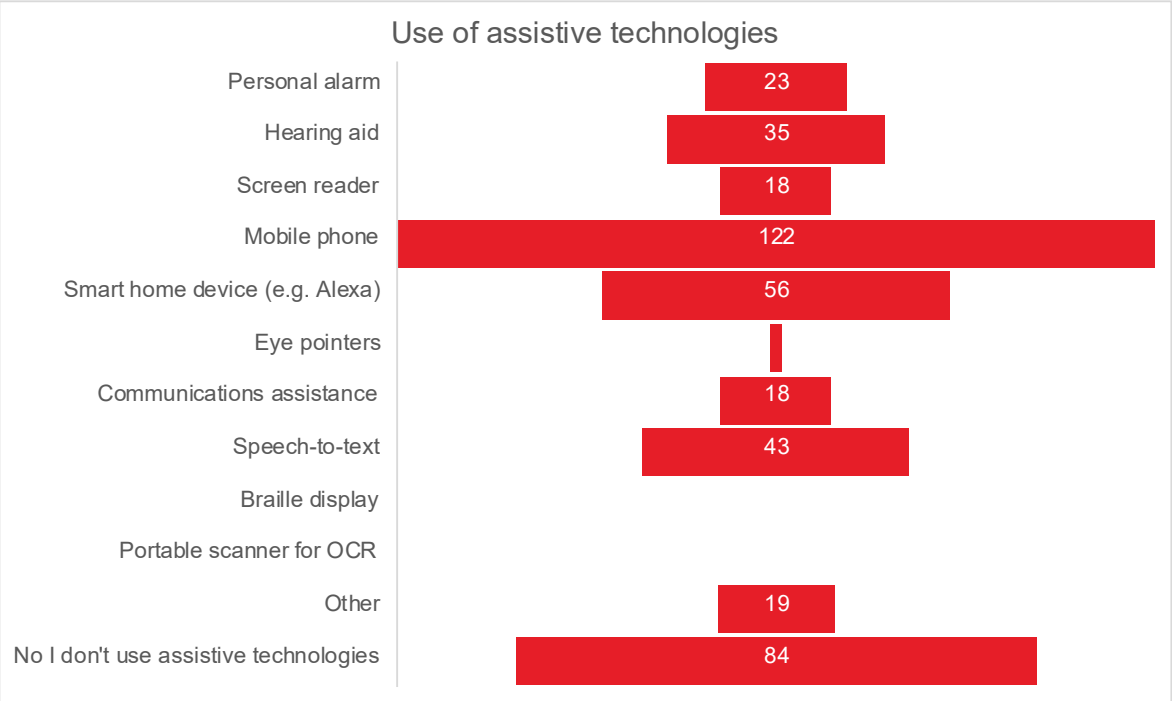


Figure 10. Number of respondents reporting the use of each assistive technology[31].

8.3.3 Need for assistance

More than 50% of survey respondents reported requiring care of some kind to carry out everyday activities. This was categorised into informal (i.e. unpaid, non-professional) or formal (i.e. paid or professional) care.

- 11% of all respondents received formal care from one or more carers or assistants.
- 50% of all respondents received informal care from one or more carers or assistants.
- 31% did not report receiving care.

Most people requiring assistance (of any type) were mobility aid users or had mobility-related disabilities (see Figure 11 and Figure 12).

12 respondents reported using assistance animals, of which 83% were in the mobility group and 75% were wheelchair users.

[31] For 'Portable scanner for OCR', OCR stands for optical character recognition. OCR technology can convert text from a scanned document or image into machine-readable text.

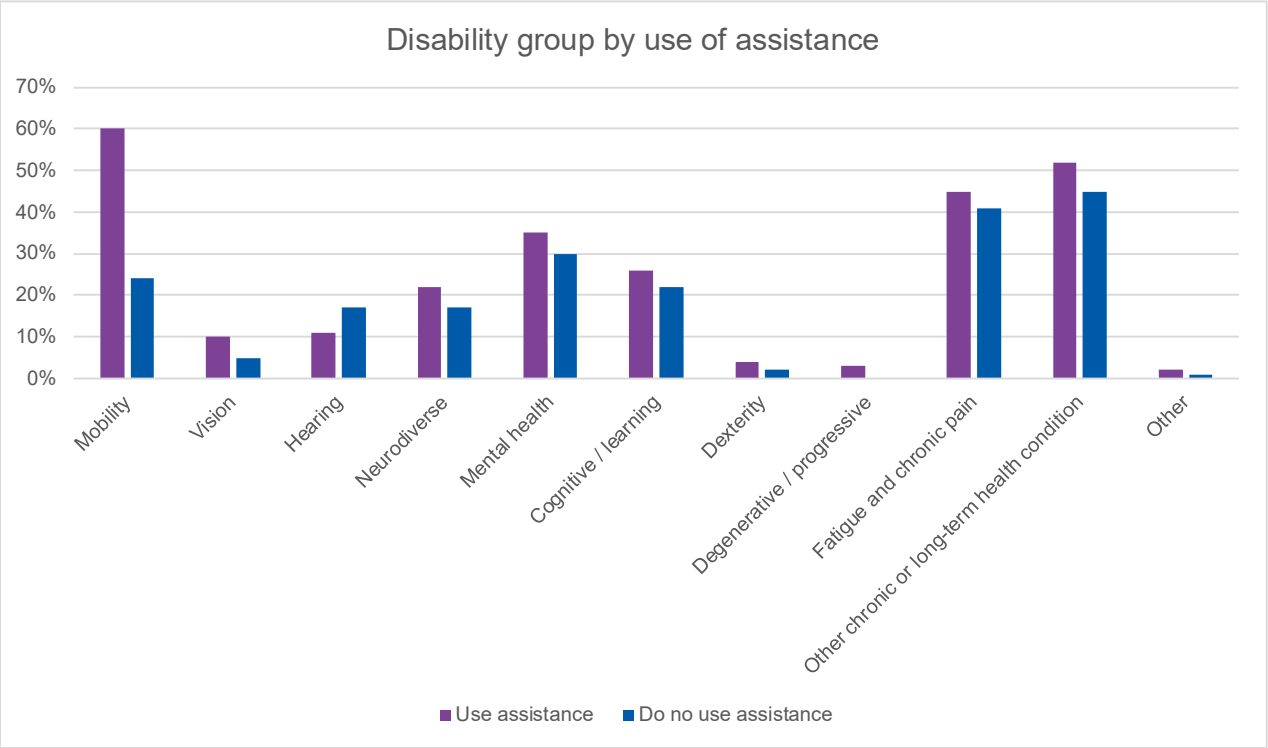


Figure 11. Disability groupings, by percentage of each group who require some form of assistance to complete everyday tasks.

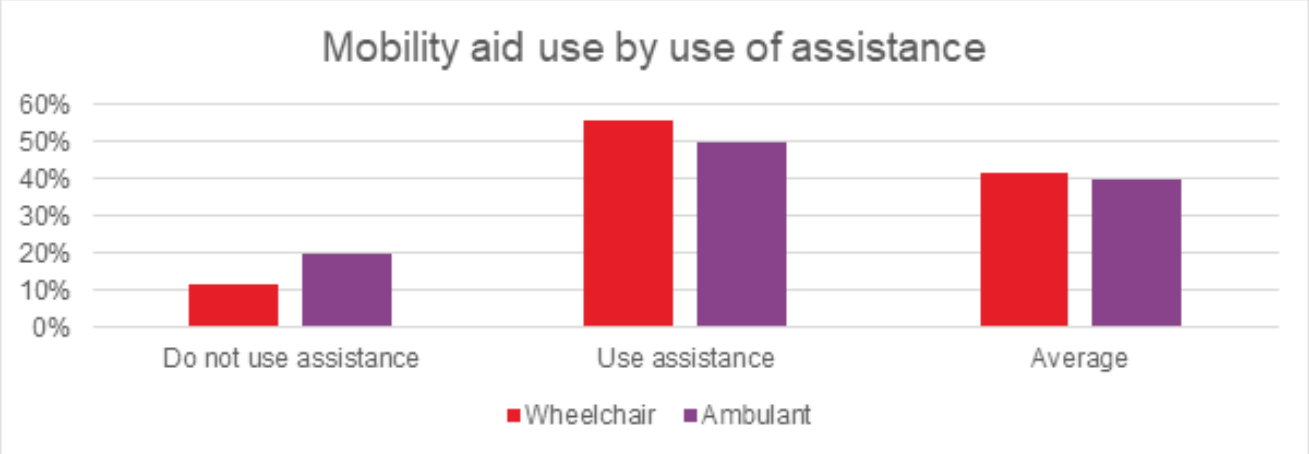


Figure 12. Percentage of wheelchair users and ambulant mobility aid users who do and do not require assistance with everyday tasks.

8.3.4 Impact of demographics on disability, condition, and use of aids

The correlation of age and sex with disability categories was analysed as part of the research. While the findings should not be generalised to the population of England (i.e. as the survey is not intended to achieve a representative population sample) they do indicate the impact of age on the barriers, helpful features, views and experiences identified in the rest of the survey analysis.

Age

Figure 13 sets out the percentage of survey respondents in each age group who reported at least one condition in each disability category compared to the average of all survey respondents[32].

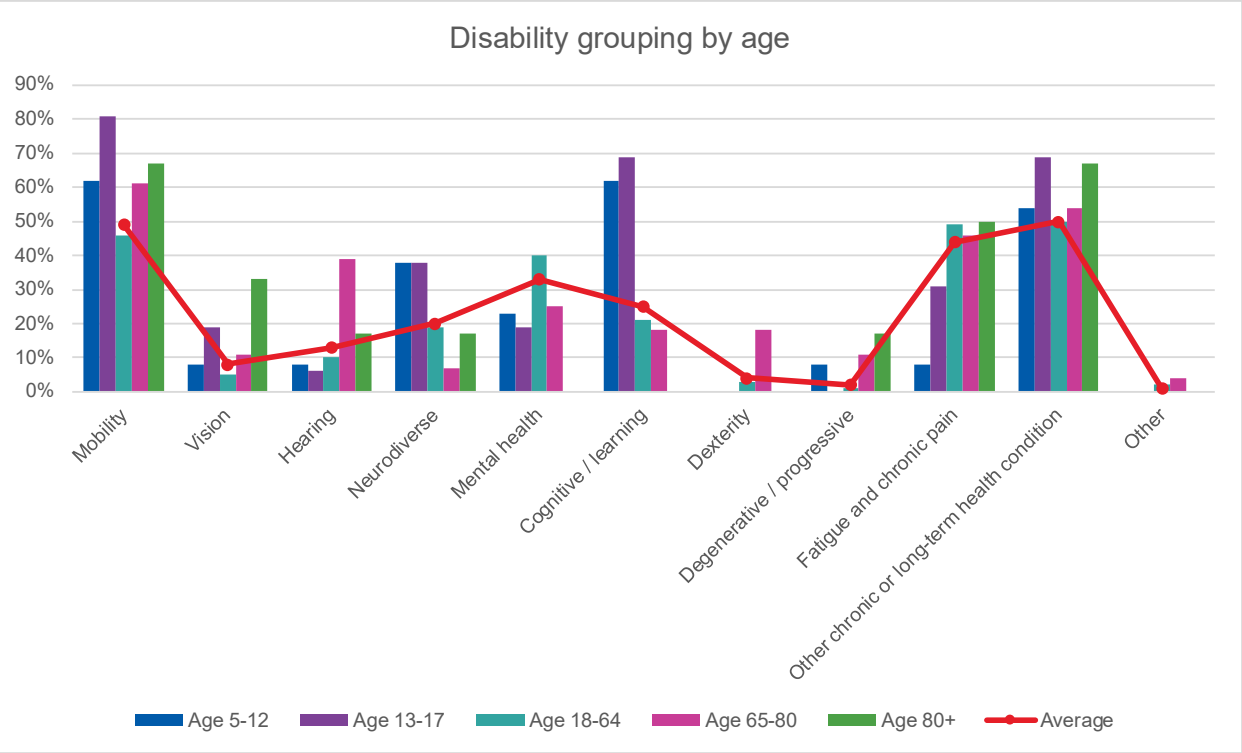


Figure 13. Prevalence of disability group by age group.

The Objective 1 research identified that the prevalence of particular disabilities differs according to age group (see Section 3.2.2) and this was also borne out by the survey findings.

- Children (under 18 years) were more likely to report in the mobility, neurodiversity, cognitive/learning and 'Other chronic or long-term health conditions' groups than the average of all survey respondents. 13-17 year olds were more likely to report in the vision group, but were less likely to report in the hearing, mental health, dexterity, and fatigue and chronic pain groups.
- Older adults (65-80 years) were more likely to report in the mobility, vision, hearing and dexterity groups. They were less likely to report in the neurodiversity, cognitive/learning, mental health and fatigue and chronic pain groups than the average of all survey respondents.
- Adults aged 80+ years were more likely to report in the mobility, vision, neurodiversity and other chronic or long-term health condition categories. The neurodiversity responses in this group were all dementia or memory related.

[32] Both the 0-4 years and 80+ years age groups have been incorporated into the nearest larger age group due to the small number of survey responses in these categories.

Sex and gender

Sex and gender responses were considered against disability groups (see Figure 14). The categories considered were legal sex (male and female), and respondents who reported that their gender identity was different to their legal sex (3% of total respondents).

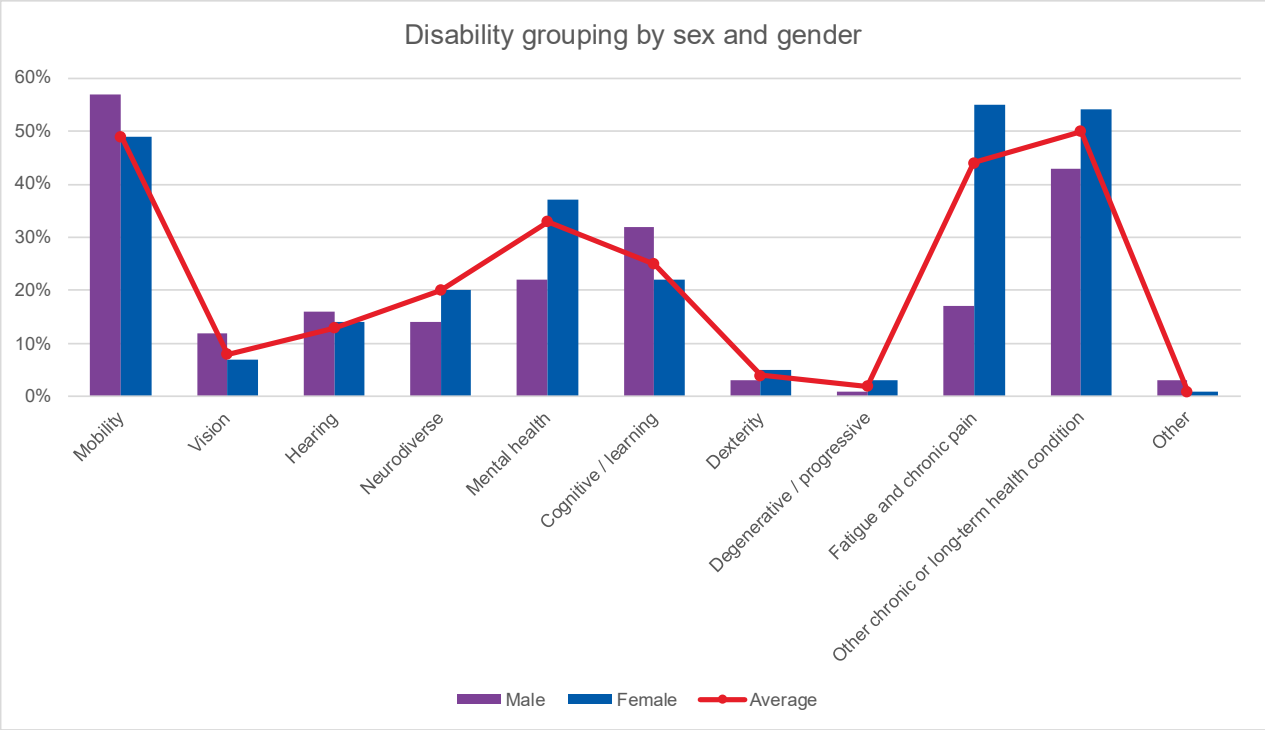


Figure 14. Proportion of respondents in each disability group by sex response[33].

- In most categories, male and female response rates were relatively similar. Women were significantly more likely to report mental health and fatigue and chronic pain groups. Women were slightly less likely to report mobility, vision and hearing issues.
- Most common conditions for women were mobility, fatigue and chronic pain, and other chronic or long-term health conditions. Most common conditions for men were mobility, other long-term condition, and learning/cognitive.
- People who reported a different gender identity were significantly more likely to report in the mobility, neurodiversity, mental health, cognitive and learning groups. However, it is difficult to extrapolate these results to the population of England as a whole given the relatively small sample size of respondents (9 people) who reported a different gender identity. The most reported conditions in this group were anxiety and stress-related mental illness (67%), autism or Asperger Syndrome (78%) and mobility disability (67%).

8.4 Barriers and helpful features

The survey asked respondents to identify any barriers and helpful features they typically encountered when completing different tasks outside their personal dwelling.

[33] Note, Figure 14 shows the percentage of respondents identifying in the male and female sex category who reported in each disability category only.

Tasks were grouped into the following categories:

- Circulation (including general circulation, vertical circulation between levels, wayfinding and evacuation etc.).
- Internal facilities (including office facilities, kitchens, counters / reception desks and seating etc.).
- Sanitary facilities.
- Operating devices and controls (including controls and devices in general (buttons, touchscreens etc) and specific devices such as ATMs and card machines.
- Environmental conditions (including a variety of conditions relating to sound, light, air quality and temperature, weather etc.).
- Wheelchair-user specific.
  - This category was specifically for wheelchair users and asked questions relating to both transfer (e.g. into seating, beds and vehicles) and use of sliding doors. These were categories specifically identified by DLUHC in the initial scope of the research project.

Task category barriers are broken down by disability category (see Section 8.4.2) and by mobility aid use category (see Section 8.4.3) to give an overview of which groups encountered which barriers. Following this, for each task category the barriers and helpful feature that was identified by the highest proportion of users is noted. The aim of this is to give an overview of what key issues are most central and most common to respondents with particular needs in the built environment.

See Section B.3 in Appendix B for detailed overview of the barriers and helpful features identified by each group.

8.4.1 Findings by task category

Figure 15 summarises the percentage of respondents who reported at least one barrier in the built environment for each of the task categories.

The most barriers were reported under tasks related to circulation (i.e. entering and circulating within buildings, and circulation using steps and stairs). Issues with operating devices and controls was reported the least by respondents.

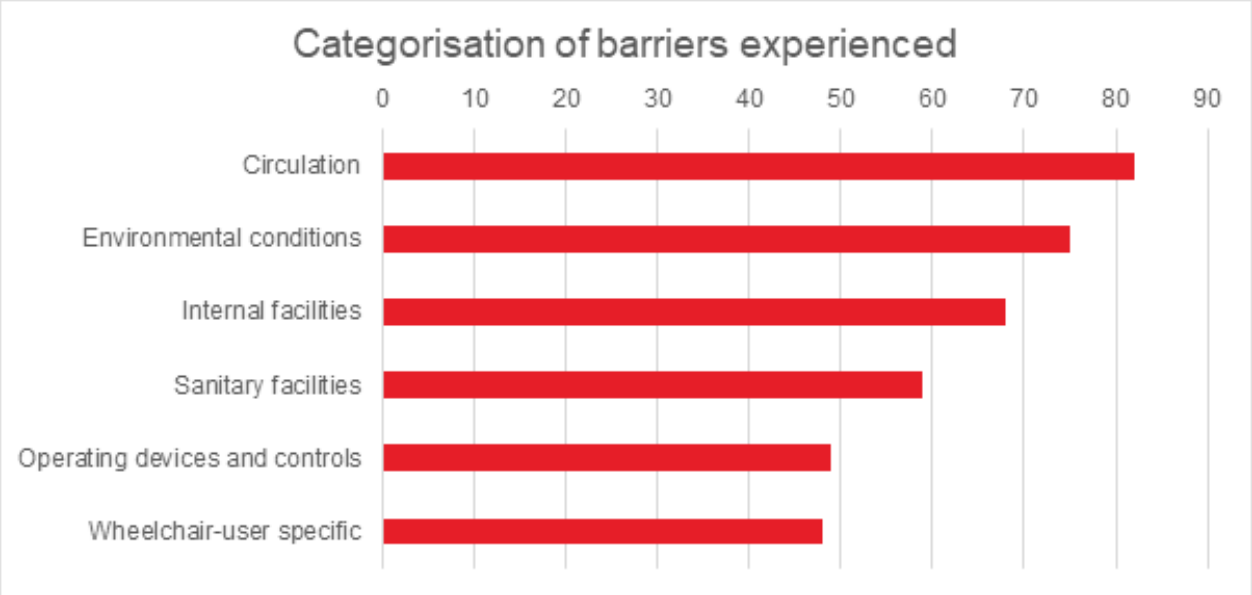


Figure 15. Percentage of respondents who reported at least one barrier in each survey category.

8.4.2 Findings by disability category

Responses between different disability categories showed variation in areas of the built environment that presented the most challenges, and variation in the specific barriers and helpful features identified.

Note, due to the format of the survey, unless respondents commented in detail about a barrier or feature in their long-answer responses, it was not possible to determine conclusively why an item was a barrier or a helpful feature.

Figure 16 shows the percentage of respondents experiencing barriers related to each task category by disability group. For example, 61% of respondents who said they encountered a barrier with circulation had a mobility-related disability.

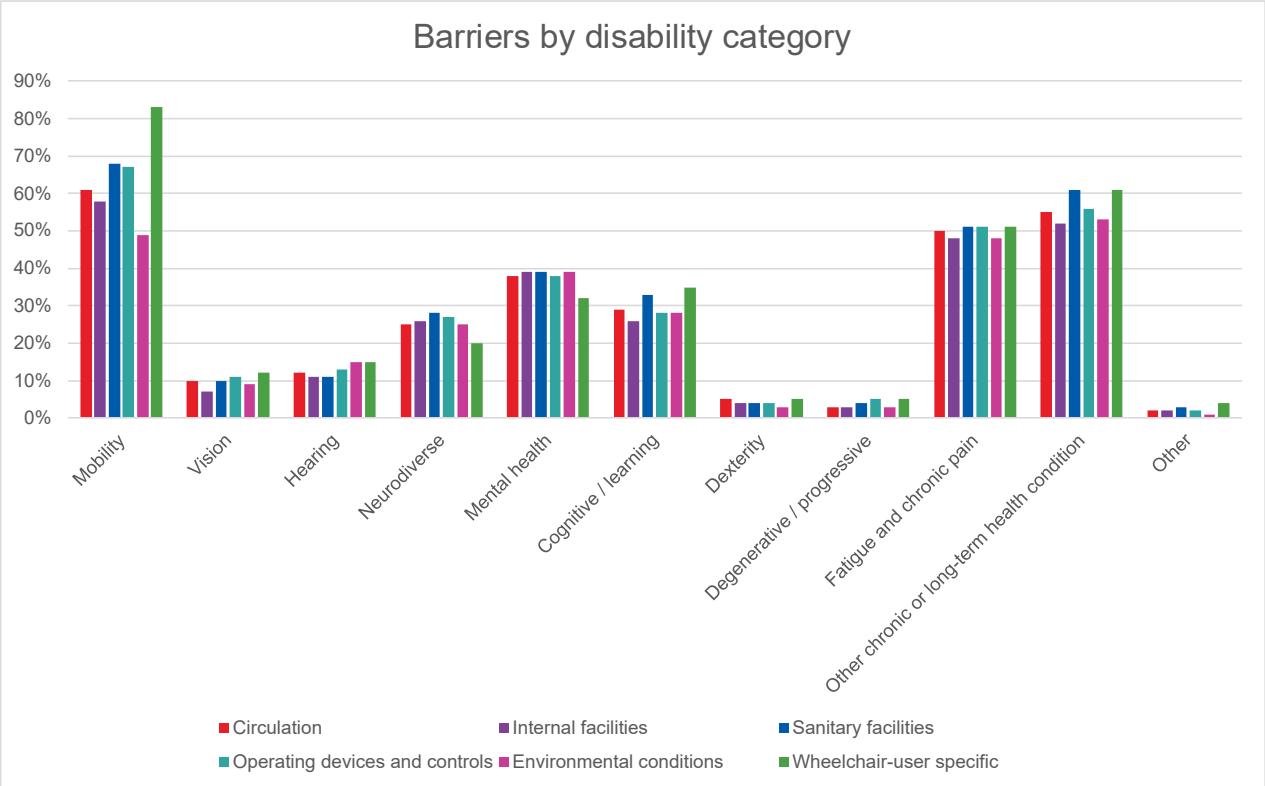


Figure 16. Percentage of respondents in each survey category by disability group.

There were some differences between the barriers encountered by respondents with specific categories of disability.

- People with mobility-related disabilities made up the highest proportion of most responses. Within this group, however, respondents were less likely to report barriers with environmental conditions and internal facilities.
- In the vision group, the most frequently identified barriers were operating devices and controls, and indicated wheelchair-user specific barriers (this can in part be attributed to the fact that 59% of respondents in the vision group were also wheelchair users).
- In the hearing group, environmental conditions were the most frequently identified barrier.

Figure 17 shows the proportion of respondents in each disability category who identified at least one barrier in a task category compared against the average for all respondents.

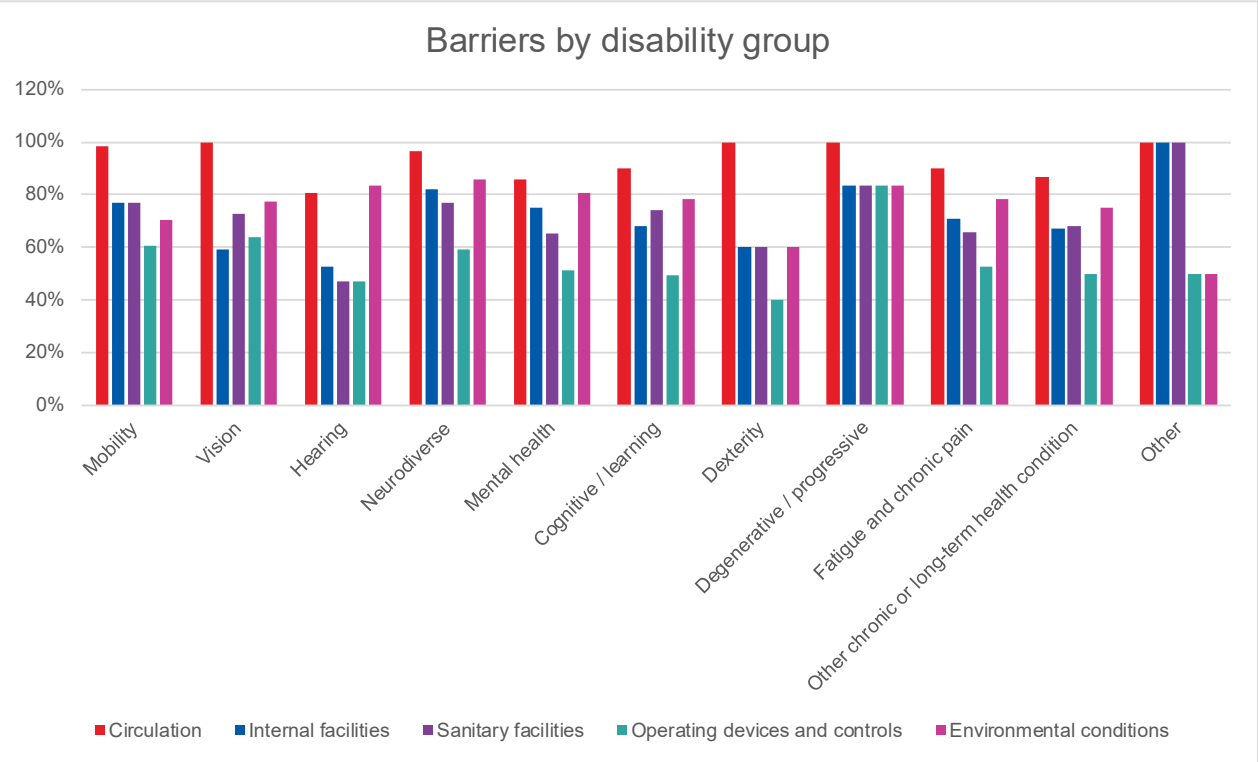


Figure 17. Percentage of respondents in each disability group who reported at least one barrier in each survey area, against overall average.

8.4.2.1 Mobility group

The mobility group provided a robust sample, with 134 respondents falling into this category (48% of all survey respondents).

Respondents with mobility-related disabilities reported a higher barrier rate than the average in all survey areas. 99% of respondents reported issues with circulation, and there was relatively high consensus about barriers to circulation, with more than 75% of respondents agreeing with barriers about doors, circulation route widths, etc.

Figure 18 shows the percentage of mobility group respondents reporting at least one barrier in each survey area, against the average rate for all respondents.

Figure 18. Percentage of respondents in mobility group reporting at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the mobility group are listed in Table 26.

Headline findings are listed below:

- 63% of people with a mobility-related disability also reported having another chronic or long-term health condition.
- 53% of people with a mobility-related disability also reported fatigue or chronic pain.
- While 93% of people with a mobility-related disability reported stairs as a barrier, only 67% reported difficulty using an escalator. However, no respondents with a mobility-related disability described having an escalator as a helpful feature.
- 71% of people with a mobility-related disability were unable to use steps altogether.
- 57% described not being able to finds a lift as a barrier, compared to 2% not being able to find stairs.
- 43% of people with a mobility-related disability experience loud background noise when speaking as a barrier.
- A small minority of mobility group respondents identified toilets being too far from a wall (for support) as a barrier (6%), with 25% identifying a toilet with space to both sides and the front (peninsular layout) as helpful.
- Shower curtains were identified as a greater barrier than shower screens (19% vs 7%) (no additional details on why were provided).
- Only 2% described push-button flushes on top of a toilet cistern as helpful, compared to 15% for a flush that can be used with an elbow and 34% for an automatic sensor flush.

Table 26. Barriers identified by at least 75% and 50% of respondents in the mobility group.

Barriers identified by at least 75% of respondents in the mobility group	Barriers identified by at least 50% of respondents in the mobility group
The type of door (revolving, swinging, sliding) The weight of the door Narrow routes or corridors Obstacles (e.g., furniture, columns) Stairs The steepness of a slope	Getting from the entry door from the street Crossing the door threshold The size / width of the door Door handle stiff / difficult to turn Pushing the door Pulling the door Using an escalator Finding the lift from the entrance Width of a lift door The height and ease of use of window opening controls Counter heights Slippery floors Uneven surfaces Rain, ice and snow

8.4.2.2 Vision group

The vision group has a relatively small sample size (22 respondents) and a high rate of co-occurrence with mobility-related disabilities (68% of people in the vision category also had a mobility-related disability). This may explain why many of the barriers identified by people in this group are related to circulation / mobility.

Figure 19 shows the proportion of people with a vision-related disability who identified at least one barrier in each task category.

Figure 19. Proportion of respondents in vision group identifying at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the vision group are listed in Table 27.

Headline findings are listed below:

- A large proportion of respondents with a vision-related disability also had a mobility-related disability (68%) and / or other chronic or long-term health condition (59%).
- The colour and pattern of floor surfaces was not seen as important, with no respondents describing a dark or pale colour as helpful, and 9% describing a dark floor as helpful. Large and consistent or repeating patterns (e.g. stripes) were identified as a barrier by 14%.
- 14% reported a lack of distinction between the wall and floor as a barrier, and 18% between a wall and other features (e.g. doors).
- 9% found tactile paving at the top and bottom of the stairs useful. 9% found level sections at the top and bottom of the handrail useful.
- 5% of respondents with a vision-related disability found Braille information (e.g., on handrails or walls) useful.
- No respondents with a vision-related disability reported mirrored surfaces as presenting a barrier.
- 18% found touch-based signage (raised letters or Braille) at standing height useful, compared to 5% at seated height.
- While background sound causing a distraction (59%), loud background noise when speaking (55%) and when navigating or moving around (55%) were all frequently reported as barriers, music was only identified as a barrier by 14%. Perhaps surprisingly, background music was identified as helpful by 23%.

- All weather conditions tested were consistently recorded as presenting a barrier by between 45%-59% of respondents, apart from overcast / cloudy weather (9%).

Table 27. Barriers identified by at least 50% and 75% of respondents in the vision group.

Barriers identified by at least 75% of respondents in the vision group	Barriers identified by at least 50% of respondents in the vision group
Obstacles (e.g., furniture, columns) Stairs	Getting to the entry door from the street Finding an entrance/exit Space to move or turn in front of a door Crossing the door threshold Floor surfaces at entrances Security gates or other access control devices Door intercoms or assistance call buttons Lack of shelter from weather conditions The type of door (revolving, swing, or sliding) The size/width of a door The type of door handle Stiffness/ease of use of a door handle The weight of a door Pushing a door Pulling a door Not being able to see what is on the other side of a door Location or position of access controls to operate the door (e.g., push pad) Narrow routes and corridors Enclosed rooms or lobbies Floor surfaces Environmental conditions (sound, light, temperature) Lack of signage, or confusing signage Using an escalator

Barriers identified by at least 75% of respondents in the vision group	Barriers identified by at least 50% of respondents in the vision group
	Finding a lift from the entrance Size of lift Steepness of slope Slippery or unstable floor surfaces Needing assistance to evacuate 'Other' barriers related to toilets Lack of space for assistance or carers in changing facilities Seeing information on a touchscreen Moving from a bright space to a dark space Slippery floors Uneven surfaces Gaps between paving slabs Rain, wind, ice and snow Background noise

8.4.2.3 Hearing group

Figure 20 shows the proportion of people with a hearing-related disability who identified at least one barrier in each task category.

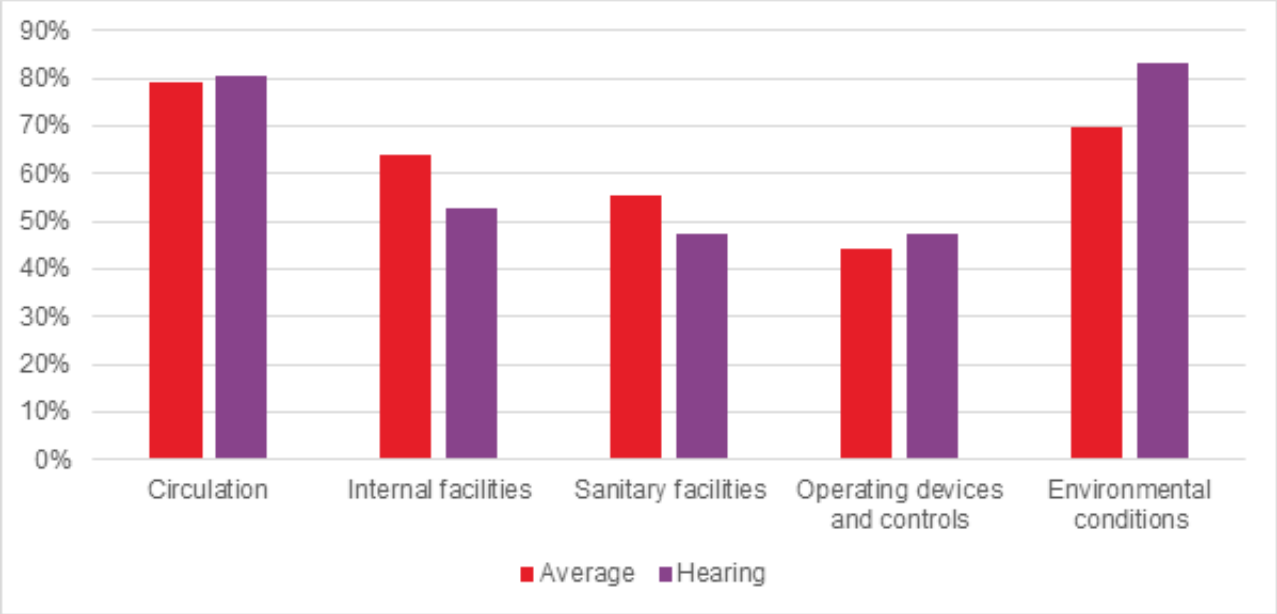


Figure 20. Percentage of respondents in hearing group who identified at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the hearing group are listed in Table 28.

Headline findings are listed below:

- 56% of respondents with a hearing-related disability also reported a mobility-related disability, and 58% some other chronic or long-term health condition.
- Respondents with hearing-related disability identified relatively few barriers or helpful features across most categories, except for environmental conditions (especially relating to background noise - identified as a barrier by 81% when speaking and 58% when navigating or moving around).
- Flashing or flickering lights were also identified as a barrier in environmental conditions (53%).
- Background music was identified as both helpful and unhelpful in roughly equal measure. 58% reported background music as helpful, with 56% reporting a lack of background music as helpful.

Table 28. Barriers identified by at least 50% and 75% of respondents in the hearing group.

Barriers identified by at least 75% of respondents in the hearing group	Barriers identified by at least 50% of respondents in the hearing group
Loud background noise when speaking	The type of door (revolving, swing, sliding) The weight of a door Narrow routes and corridors Stairs Flashing or flickering lights Slippery floors Uneven surfaces Loud background noise when navigating or moving around Echoing spaces Background sounds causing distraction

8.4.2.4 Neurodiversity group

Figure 21 shows the proportion of people with a neurodivergent condition who identified at least one barrier in each task category.

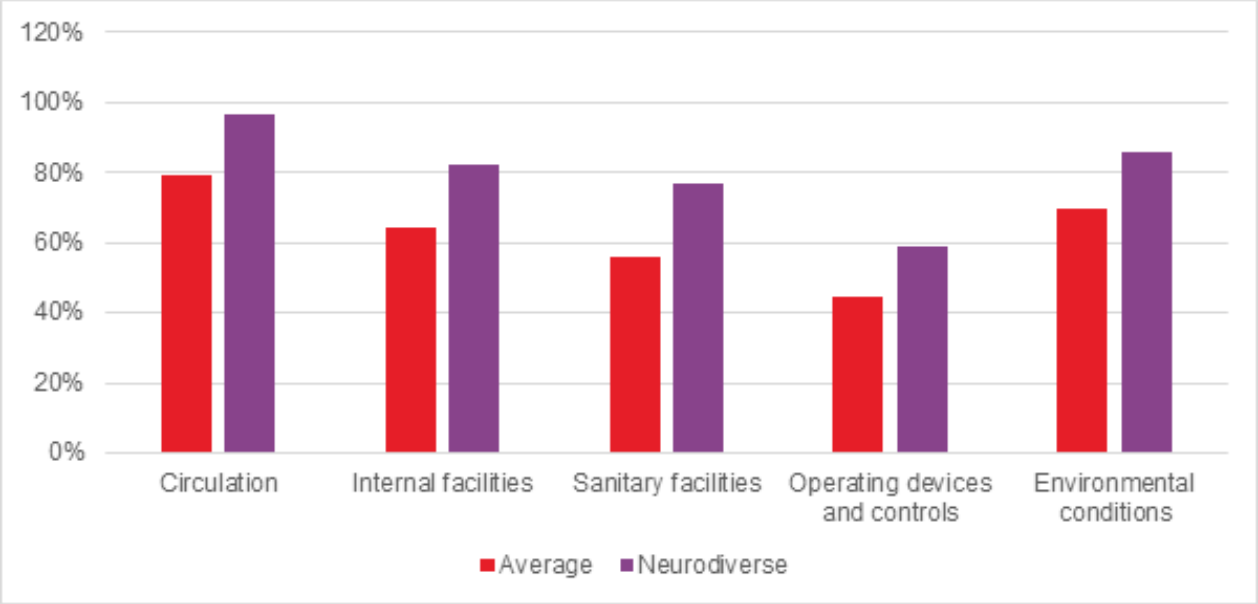


Figure 21. Proportion of respondents in neurodiverse group who identified at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the neurodiversity group are listed in Table 29.

Headline findings are listed below:

- 66% of respondents with a neurodivergent condition also had some other chronic or long-term health condition, 55% a mobility-related disability, and 52% a mental health condition.
- A majority identified quiet space as helpful in both circulation space (54%) and offices (52%).
- Standing, waiting and queuing was identified as a barrier across a number of situations, including generally on circulation routes (57%), waiting for lifts (52%), and waiting to use sanitary facilities (50%).
- Most people with neurodivergent conditions identified evacuation features or procedures as helpful, including evacuation lifts (55%), a person / people to help them evacuate (54%), and having an evacuation plan in advance (52%). The need for assistance and evacuation plans is similar to that for people with a mobility-related disability (58% and 57% respectively).
- While a minority of neurodiverse respondents reported barriers wall and floor colours, tone or reflective surfaces, they were more than twice as likely to be impacted than the average across all disability categories.
- 25% of neurodiverse respondents reported barriers associated with a lack of distinction between walls and floors, compared to an average across all disability categories of 11% and 14% for the vision group.
- Although only impacting a minority, neurodiverse respondents were more than twice as likely as the average across all disability categories to identify open-plan environments as a barrier (21% vs 9%) and twice as likely to identify enclosed rooms as helpful (20% vs 10%).
- The hygiene of devices and controls was identified as a barrier by more people with neurodivergent conditions than other disabilities, with 32% being concerned about hygiene at ATMs and 27% at payment devices (compared to 6% and 5% across all disability categories).
- Both background music and the lack of background music were identified as helpful (48% and 41%), suggesting significant variation within this category.
- Neurodiverse respondents were more than twice as likely to describe a humming or noise from lighting as a barrier, compared to the average across all disability categories (66% vs 32%).
- 52% of neurodiverse respondents found headphones or personal noise control devices as helpful.

Table 29. Barriers identified by at least 50% and 75% of respondents in the neurodiverse group.

Barriers identified by at least 75% of people with a neurodivergent condition	Barriers identified by at least 50% of people with a neurodivergent condition
The weight of a door	Finding the entrance/exit of a building
Stairs	The type of door (revolving, swing, sliding)
Loud background noise when speaking	Door handles that are stiff/difficult to turn
Loud background noise when navigating or moving around	Pushing a pulling a door
	Narrow routes and obstacles
	Standing still or waiting
	Lack of signage, or confusing signage
	Using an escalator
	Finding the lift from the entrance of a building
	The length of time waiting for a lift
	Queueing or waiting to use a toilet
	Steepness of slopes
	Confusing layouts
	Confusing signage
	Dry space to store items when showering
	High light levels (too much light)
	Flashing or flickering lights
	Glare or reflection on surfaces
	Humming/noise from lighting
	Moving from a dark space from a light space
	Slippery floors
	Uneven surfaces
	Gaps between paving slabs
	Reflections or glare
	Hot spaces
	Air conditioning
	Sudden changes in temperature

Barriers identified by at least 75% of people with a neurodivergent condition	Barriers identified by at least 50% of people with a neurodivergent condition
	Rain Ice and snow Echoing spaces Background sounds causing distraction Particular unpleasant sounds

8.4.2.5 Mental health conditions group

Figure 22 shows the proportion of people with a mental health condition who identified at least one barrier in each task category.

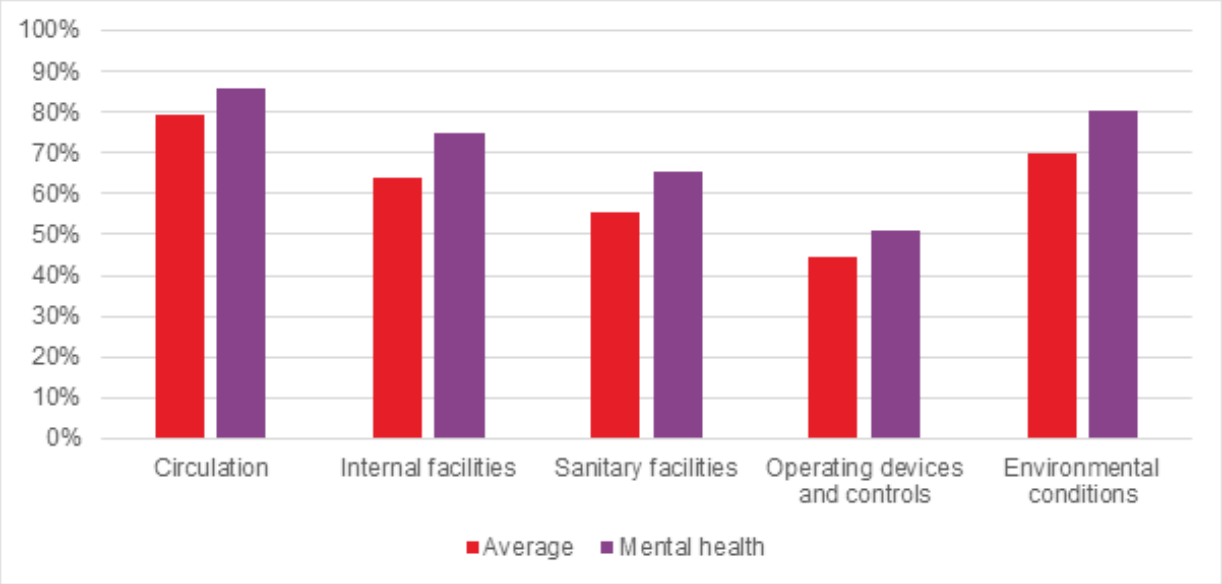


Figure 22. Proportion of respondents in mental health conditions group who identified at least one barrier in each survey category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the mental health conditions group are listed in Table 30.

Headline findings are listed below:

- 63% of respondents also reported fatigue or chronic pain, and 61% some other chronic or long-term health condition.
- Barriers and helpful features reported under circulation were broadly similar to the average across all disability categories, with the exceptions of provisions of quiet spaces (46% vs 28%) and resting or seating areas (54% vs 39%) being identified as helpful.

- Although impacting a minority, respondents were twice as likely than the average across all disability categories to identify large (16% vs 8%) and consistent and repeating patterns (24% vs 12%) on floors.
- Respondents were more likely than the average across all disability categories to identify desk space (42% vs 30%), adjustable seating (33% vs 22%) and back rests (38% vs 24%) as helpful.
- 21% of respondents identified barriers related to sensitivities to different materials, compared to 8% across all disability categories.
- Respondents identified broadly similar barriers and helpful features within sanitary facilities but were significantly more likely than the average across all disability categories to identify a lack of seating in changing rooms (46% vs 28%), dry space in showers (42% vs 28%) and the need to queue and wait to use a toilet (38% vs 27%) as barriers.
- Both background music (49%) and a lack of background music (45%) were identified as helpful in roughly equal measure.
- 48% of respondents identified barriers relating to environmental conditions (e.g., light, sound, temperature) in office environments, compared to 26% across all disability categories.
- 38% of respondents identified control over light levels as helpful, compared to 22% across all disability categories.

Table 30. Barriers identified by at least 50% and 75% of respondents in the mental health group.

Barriers identified by at least 75% of respondents in the mental health group	Barriers identified by at least 50% of respondents in the mental health group
(None)	The type (52%) and weight (68%) of doors Door handles that are stiff/difficult to turn Narrow routes and corridors (54%) and obstacles (54%) Stairs (67%) Steep slopes (51%) Flashing or flickering lights (59%) Humming/noise from lighting (52%) Slippery (55%) or uneven (53%) floors Hot spaces (58%) Air conditioning (51%) Ice and snow (52%) Loud background noise when speaking (70%) or navigating or moving around (55%) Echoing spaces (50%) Background sounds causing distraction (58%) Particular unpleasant sounds (54%)

8.4.2.6 Cognitive / learning disabilities group

Figure 23 shows the proportion of people with cognitive / learning disabilities who identified at least one barrier in each task category.

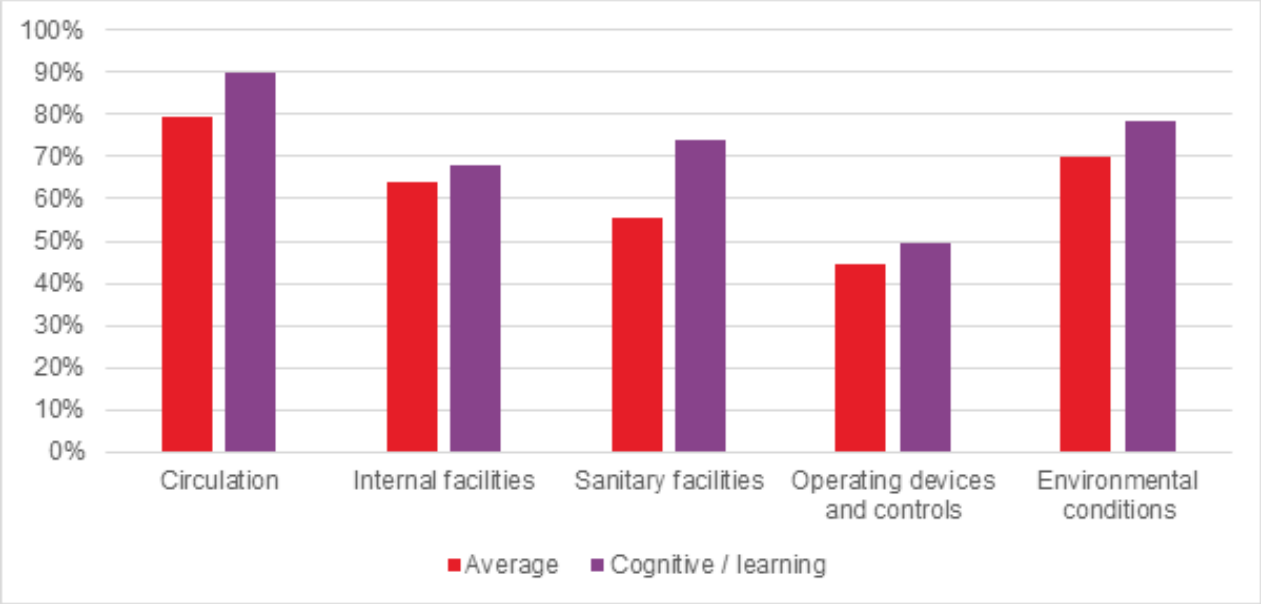


Figure 23. Proportion of respondents in cognitive / learning disabilities group who identified at least one barrier in each survey category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the cognitive / learning disabilities group are listed in Table 31.

Barriers and helpful features identified by people in the cognitive / learning disabilities group were broadly similar to the average across all disability categories.

Headline findings are listed below:

- 65% of respondents also had a mobility-related disability, and 64% of respondents some other chronic or other long-term health condition. 51% described themselves as unable to use stairs.
- Respondents were twice as likely as the average across all disability characteristics to identify sensitivity to different materials as a barrier (20% vs 8%), especially rough surfaces (19% vs 8%) and surfaces that are wet to the touch (26% vs 13%).
- Respondents were twice as likely than the average across all disability categories to identify a touch-free environment (with a minimised need to touch surfaces) as helpful (30% vs 15%).
- 41% of respondents identified a lack of space for other people (i.e. assistance or dependents) in WCs as a barrier, compared to 20% of respondents across all disability categories.
- 41% of respondents identified a changing table to get dressed or for personal care as helpful; and 29% of respondents identified a hoist within toilet facilities as helpful.
- 23% of respondents identified a shower curtain as a barrier, compared to 7% identifying a shower screen as a barrier.

- Within toilet facilities, respondents were more than twice as likely than the average across all disability categories to identify the environment conditions (26% vs 10%), visual appearance (13% vs 5%) and the materials used within the room (17% vs 7%) as barriers.

Table 31. Barriers identified by at least 50% and 75% of respondents in the cognitive / learning disabilities group.

Barriers identified by at least 75% of respondents in the cognitive / learning disabilities group	Barriers identified by at least 50% of respondents in the cognitive / learning disabilities group
(None)	Getting to the entry door from the street The type of door (revolving, swing, sliding) The size/width of doors The weight of doors Pushing and pulling doors Narrow routes and obstacles Stairs Using an escalator Finding lifts from the entrance of a building The size of lifts Steepness of a slope 'Other' barriers in WCs Slippery and uneven floors Hot spaces Rain, ice and snow Loud background noise when speaking Loud background noise when navigating or moving around

8.4.2.7 Dexterity group

A sample size of 10 respondents reported a dexterity-related disability; therefore, a full breakdown of barriers and helpful features affecting this group was not possible.

Of the 10 respondents with a dexterity-related disability:

- 9 were also a member of at least one other disability category.
- 7 had a mobility-related disability.
- 7 had some other chronic or long-term health condition.

- 6 experienced fatigue or chronic pain.

All but one respondent, therefore, has been included under at least one other disability category.

One reason for the low sample size is likely to be the relatively low response rate by older people (65+ years, 80+ years) to the survey. The Objective 1 research (see Section 3.2.2) indicated that dexterity issues are more prevalent in older populations, and 50% of the dexterity responses in the survey were in these age groups. It may also be that some respondents had complex conditions with a variety of impacts and did not report issues with dexterity directly.

This is not considered to be a hugely significant barrier to the survey analysis as it is clear from the responses that dexterity-related barriers were identified by respondents belonging to different disability groups. For example, 17% of all survey respondents reported that touchscreen actions requiring two simultaneous movements – e.g. using two fingers to zoom – was a barrier. This is an issue commonly associated with dexterity and precise hand movement.

8.4.2.8 Degenerative and progressive[34] conditions groups

A sample size of 6 respondents reported a degenerative / progressive condition; therefore, a full breakdown of barriers and helpful features affecting this group was not possible.

Of the 6 respondents with a degenerative / progressive condition, 3 were also a member of at least one other disability category and all respondents reported they use a wheelchair at least some of the time (so their responses are included in the findings for wheelchair users (see Section 8.4.3.1).

Degenerative and progressive conditions are complex and may present in different ways across the course of a person's life. The survey response indicates that taking measures to accommodate wheelchair use and assistants could help to accommodate those experiencing the effects of degenerative and progressive conditions.

8.4.2.9 Fatigue and chronic pain group

Figure 24 shows the proportion of people with fatigue / chronic pain who identified at least one barrier in each task category.

[34] Progressive conditions generally refer to conditions that have increasing impact on a person's health and / or abilities over time, although this may vary both by individual and condition, and are considered non-life-threating. Degenerative conditions generally refer to conditions that lead to deteriorating health over time. For example, Essential tremor is considered a progressive condition and Parkinson's disease a degenerative condition.

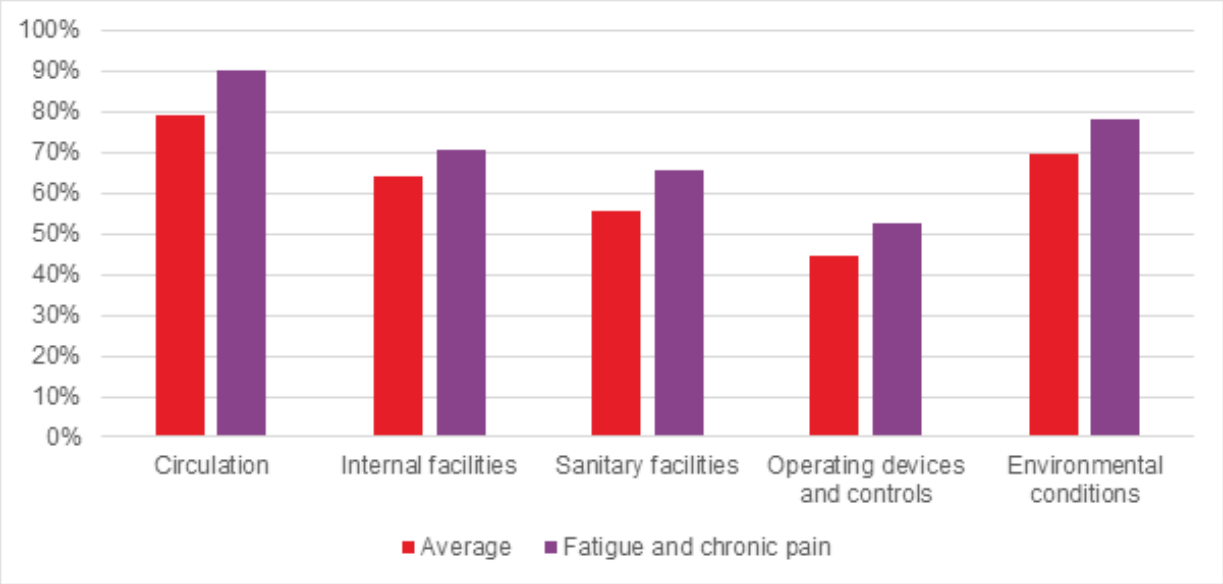


Figure 24. Proportion of respondents in fatigue and chronic pain group who identified at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the fatigue and chronic pain group are listed in Table 32.

Headline findings are listed below:

- 72% of respondents also had some other chronic or long-term health condition. 59% had a mobility-related disability and 48% use a wheelchair at least some of the time.
- 53% of respondents identified tiredness, fatigue or pain when using steps as a barrier in the built environment.
- 51% of respondents found it useful to have somewhere to ask for assistance at the entrance of a building, compared to an average 34% across all disability categories.
- 46% of respondents identified tiredness, fatigue or pain when waiting for or standing in a lift as a barrier, compared to an average of 22% across all disability categories.
- Temperature and humidity were frequently identified as barriers, with 58% identifying barriers in hot spaces and 40% in cold.
- 43% of respondents identified air conditioning as a barrier, and 49% identified air conditioning as a helpful feature.
- 39% of respondents identified sudden changes in temperature as a barrier.
- 42% of respondents identified background music as a helpful feature, and 38% identified a lack of background music as a helpful feature.

Table 32. Barriers identified by at least 50% and 75% of respondents in the fatigue and chronic pain group.

Barriers identified by at least 75% of respondents in the fatigue and chronic pain group	Barriers identified by at least 50% of respondents in the fatigue and chronic pain group
The weight of a door Stairs	Getting to an entry door from the street The type of door Both pushing and pulling a door Stiff or difficult to turn door handles Narrow routes or corridors Obstacles (e.g., furniture, columns) Walking or moving long distances Standing still or waiting Tiredness, fatigue or pain when using steps Finding a lift from the entrance of a building The steepness of a slope Flashing or flickering lights Slippery floors Uneven surfaces Gaps between paving slabs Hot spaces Ice / snow

8.4.2.10 Other chronic or long-term condition group

This category incorporated a wide-ranging set of conditions that could have varying degrees of severity and impact on use of the built environment. Findings for this category were relatively similar to the findings for the survey average as a whole, and the rate of co-occurrence of disability with another category is high at 91%, indicating that these findings may not indicate anything significant about the experience of having a health condition, as respondents may have been reporting other needs.

Figure 25 shows the proportion of people with some other chronic or long-term condition who identified at least one barrier in each task category.

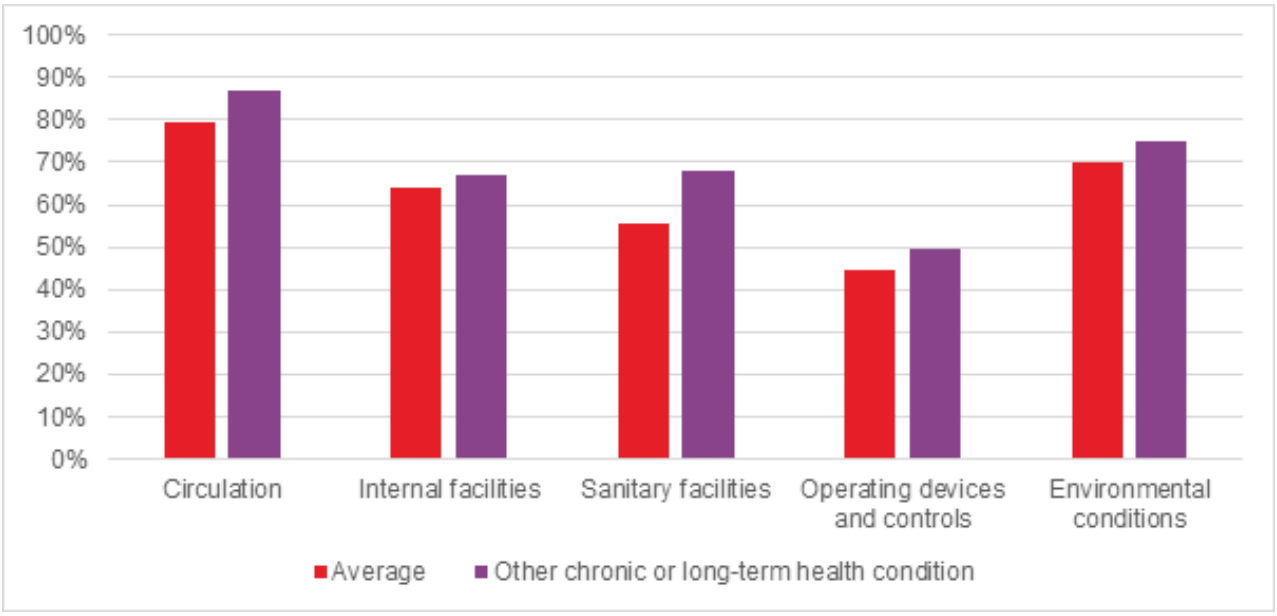


Figure 25. Proportion of respondents in the other chronic or long-term health condition group who identified at least one barrier in each task category, against average for all respondents.

Barriers identified by at least 75% and 50% of respondents in the other chronic or long-term condition group are listed in Table 33.

Headline findings are listed below:

- 63% of respondents also experienced pain and fatigue. 62% also had a mobility-related disability and 49% use a wheelchair at least some of the time.
- While 79% of respondents identified stairs as a barrier, only 54% identified a barrier in using an escalator. However, no respondents identified an escalator as a useful feature.
- Respondents were significantly more likely than the average across all disability categories to identify the lack of dry space to store items when showering as a barrier (40% vs 28%) and to identify extra space within a shower room as helpful (39% vs 29%)
- 43% of respondents identified air conditioning as a barrier, compared to 38% who identified it as a useful feature.

Table 33. Barriers identified by at least 50% and 75% of respondents in the other chronic or long-term health condition group.

Barriers identified by at least 75% of respondents in the other chronic or long-term condition group	Barriers identified by at least 50% of respondents in the other chronic or long-term condition group
Stairs	Getting to the entry door from the street The type of door (revolving, swing, sliding) The weight of a door Door handles that are stiff or difficult to turn Pushing a door Pulling a door Narrow routes and corridors Obstacles (e.g., furniture, columns) Finding a lift from the entrance Steepness of a slope Slippery floors Hot spaces Ice and snow Loud background noise when speaking

8.4.3 Findings by mobility aid use

To evaluate the impact of mobility aid use, respondents have been divided into three categories:

- Wheelchair users – respondents who identified they use wheelchairs.
- Ambulant mobility aid users – respondents who identified they used an ambulant mobility aid only (i.e. wheelchair users excluded).
- Non-mobility aid users – respondents who did not select a wheelchair or ambulant mobility aid.

Figure 26 shows the percentage of respondents from each category who reported at least one barrier in each task category. In all categories except environmental conditions, the highest proportion of mobility aid users who reported a barrier were wheelchair users.

Respondents who used no mobility aid had the lowest response rate in all categories except sanitary facilities and environmental conditions. For barriers encountered in sanitary facilities, people who used ambulant mobility aids had a lower response rate than people who did not use mobility aids.

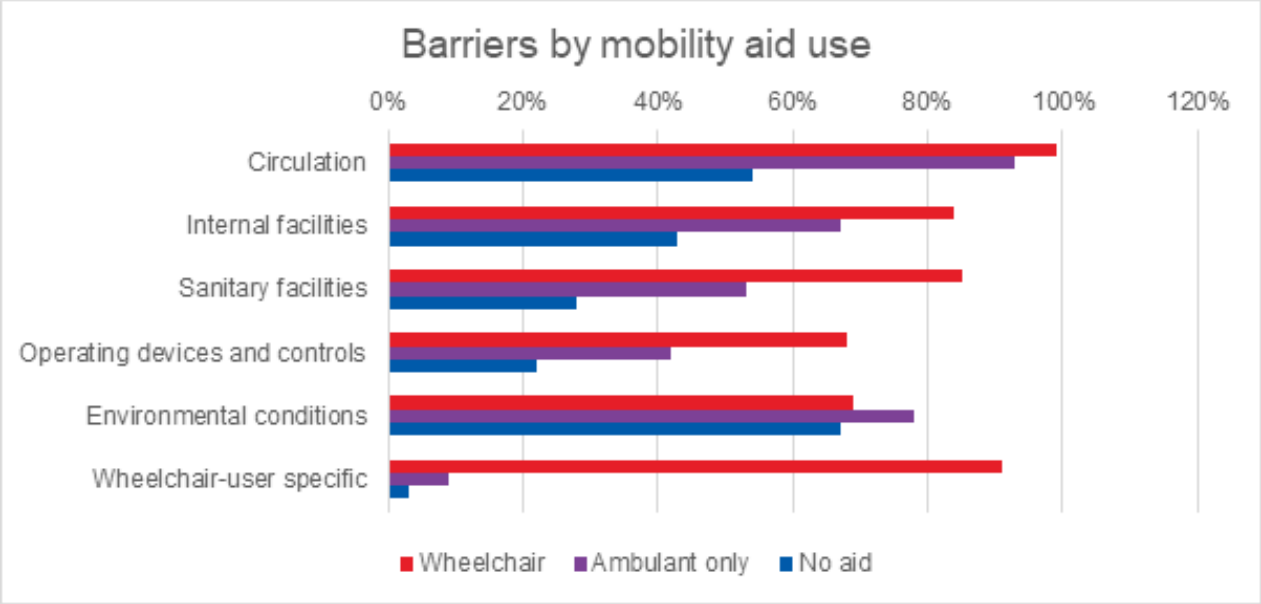


Figure 26. Percentage of respondents who reported at least one barrier in every task category by mobility aid use.

8.4.3.1 Wheelchair users

Figure 27 shows the proportion of wheelchair users who identified at least one barrier in each task category.

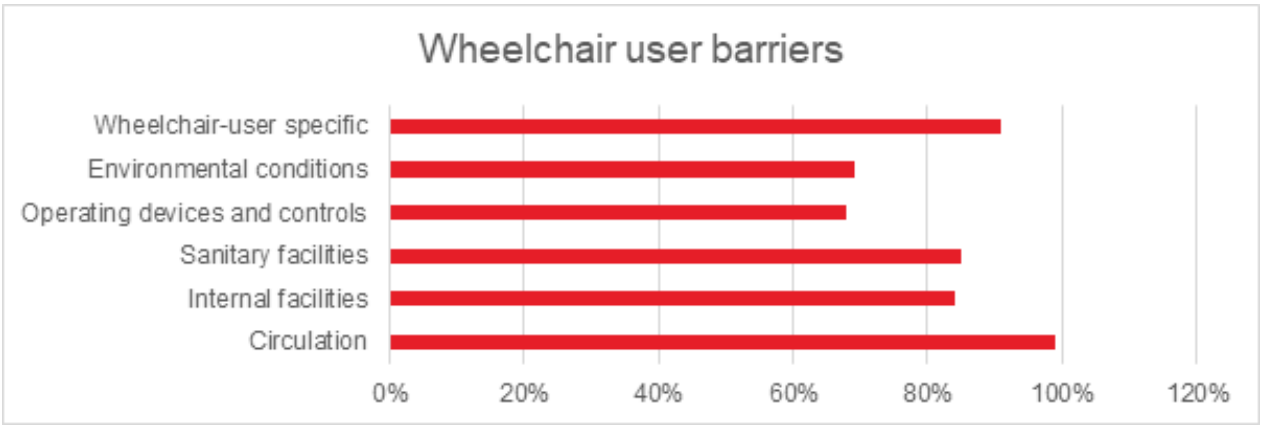


Figure 27. Percentage of wheelchair users identifying at least one barrier in each survey category.

Barriers identified by at least 75% and 50% of wheelchair user respondents are listed in Table 34. These barriers may not have been reported by most respondents but are helpful to give an overview of the most common issues.

Headline findings are listed below:

- Wheelchair users, as compared to the average survey response, reported less barriers with visual features of the environment (e.g. wall surfaces, lighting) but significantly more barriers with physical aspects of the environment (floor surfaces, weather conditions and shelter, in particular shelter at building entrances).

- Majority of wheelchair users preferred a longer but shallower ramp (65%) to a shorter but steeper ramp (2%).
- There did not seem to be a strong preference for transfer direction to seating – e.g. 89% of wheelchair users who selected that space to the left-hand side of seating was helpful also selected space to the right-hand side. There was a stronger handed preference for bed transfer, with only 57% of people who selected left-side transfer also selecting right-side transfer.
- 54% of respondents reported that they sit permanently in their wheelchairs and do not transfer to seating when not at home.
- Fear of getting stuck / injured was cited in 5 responses as a reason why people chose not to transfer to seating when outside their home.
- Some vehicle transfer responses identified a lack of accessible services, such as public transport or accessible taxi provision, as a barrier.
- 85% of respondents reported they would typically use the 'accessible' or 'disabled' toilet.
- 60% of respondents reported requiring assistance to use sanitary facilities.
- 30% identified a peninsular layout would be helpful.
- A limited number of responses preferred being able to reach a basin from the WC pan (15%) as compared to those who preferred more space in front of the basin (39%).

Table 34. Barriers identified by at least 50% and 75% of wheelchair user respondents.

Barriers identified by at least 75% of wheelchair users	Barriers identified by at least 50% of wheelchair users
Obstacles on route (e.g. furniture, columns)	Space in front of doors to move or turn around
Stairs and steps	Floor surfaces at entrances
Approaching entrance from street	Type of door handle and stiffness of door handle
Crossing the threshold	Pushing the door
Door weight, type and width	Location or position of door access controls
Pulling the door	Enclosed rooms or lobbies
Narrow routes	Finding the lift from the entrance
Escalators	Width of lift door
Size of lift	Height or position of lift controls
Steepness of ramp / slope (no other barriers above 50%)	Not being able to find the lift

Barriers identified by at least 75% of wheelchair users	Barriers identified by at least 50% of wheelchair users
	Needing assistance to evacuate Evacuating with a mobility aid Lack of refuge space Height of desk and lack of space under desk Kitchen counter height Height or position of shelves Reaching taps or controls Lack of space to move or turn around in kitchens Height of window opening controls, and stiff or hard to use controls Reception counter height and knee space 'Other' toilet barriers Height of ATM machines Slippery floor surfaces Uneven floor surfaces Floor surfaces that are hard to move over (e.g. deep pile carpets) Gaps between paving slabs Rain, ice and snow

8.4.3.2 Ambulant mobility aid users

Ambulant mobility aid users were less likely to report being unable to use steps at all as compared to wheelchair users (29% as opposed to 82%), but steps were still reported as a significant barrier. It was specific features of steps, particularly the number of steps in a flight, the height of steps, and a lack of handrails, that posed a barrier to most respondents.

Barriers identified by at least 75% and 50% of wheelchair user respondents are listed in Table 35.

Headline findings are listed below:

- 29% of respondents reported being unable to use steps.
- 58% of respondents would find lifts to evacuate helpful.
- 0% reported that a shorter, steeper ramp was preferable to a longer, shallower one.

- Seating and rest areas were a key and commonly identified helpful feature, by 73% of ambulant mobility aid users. This included seating in communal kitchens (32%) and beside lifts (49%).
- 20% of respondents indicated a desire for seating or rest areas in communal or office kitchens.
- 67% reported using accessible toilet, shower or changing facilities when available. 84% did not require assistance to use sanitary facilities.
- Respondents were more likely to report sensitivity to temperature than the average survey response (44% vs 27%). Similarly to wheelchair users, 40% reported air conditioning as a barrier while 47% identified it as a helpful feature.

Table 35. Barriers identified by at least 50% and 75% of respondents of ambulant mobility aid users.

Barriers identified by at least 75% of ambulant mobility aid users	Barriers identified by at least 50% of ambulant mobility aid users
Door weight Stairs	Walking or moving long distances, standing still, or waiting Too many steps in a flight Lack of handrails Tiredness, fatigue or pain when using steps Finding the lift from the entrance Steepness of a ramp Difficulty using stairs during an evacuation Slippery or uneven floor surfaces Hot spaces Ice / snow Loud background noise

8.4.3.3 Non-mobility aid users

Specific barriers for non-mobility aid users have not been identified here at length as there was limited consensus about what presented a barrier or helpful feature, due to the wide range of disabilities and conditions experienced by non-mobility aid users who responded to the survey. Instead, it is recommended to refer to Section 8.4.2 for a breakdown of barriers by disability category.

However, headline findings include:

- Respondents who did not use mobility aids tended to report fewer barriers overall and showed most consensus in the 'Environmental conditions' section of the survey.

- Only one item (loud background noise when speaking) was identified by more than 50% of non-mobility aid users as a barrier.
- The most identified helpful feature was natural light as an environmental condition, at 44%.

Figure 28 shows the percentage of respondents (who did not use a mobility aid) for each disability group.

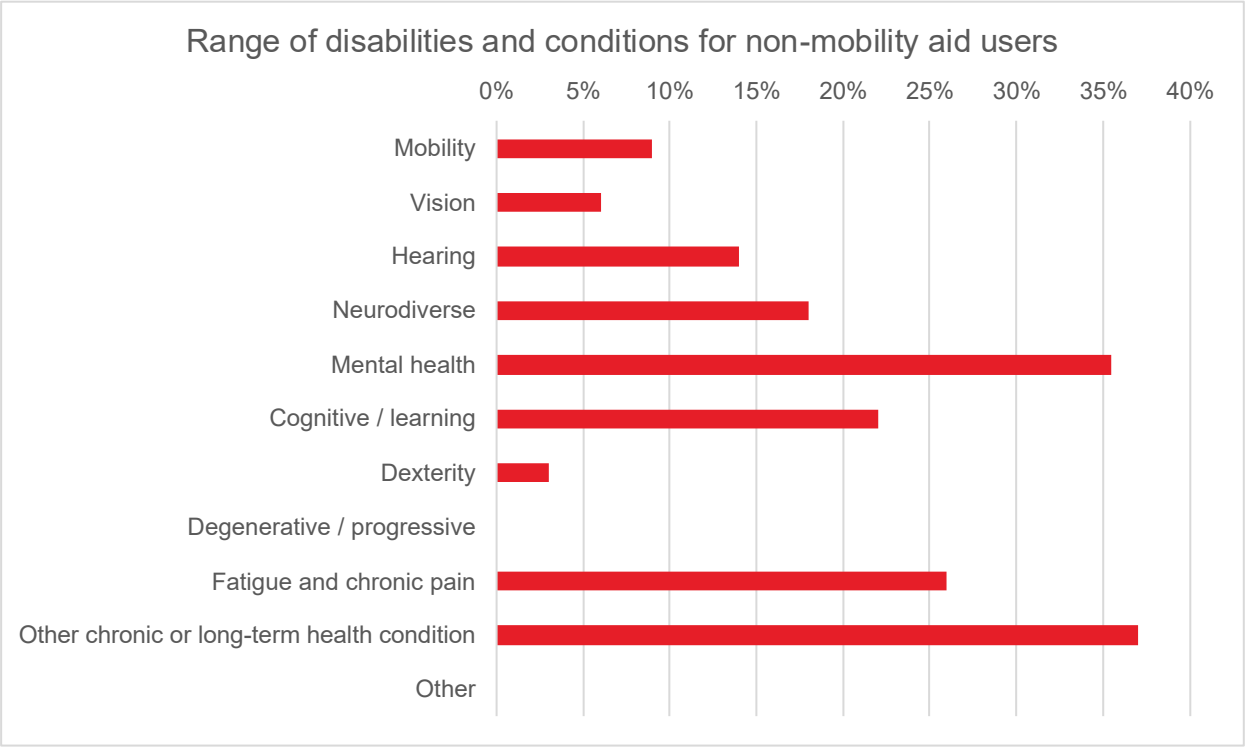


Figure 28. Prevalence of each disability group among respondents who did not report using a mobility aid.

8.5 Views and experiences

The survey gave respondents the opportunity to identify their most significant barriers and experiences and to provide personal, long-answer responses to the questions. This was important for the research as it allowed respondents to reveal what is most important to their own experience of the built environment without limitation (i.e. by multiple-choice answers).

All survey responses have been reviewed and grouped into common themes that are discussed in this section. The percentage of respondents who identified each theme has been recorded.

Example quotes from the long-answer responses relating to each theme are also included (provided in bold). Note, quotes are provided verbatim from responses provided; due to the format of the survey, it was not possible to seek clarification on individual responses.

8.5.1 Overall satisfaction

Respondents were asked to rate how satisfied they were, in general, with how spaces met their needs (see Figure 29). 61% of respondents were highly unsatisfied or unsatisfied with how spaces meet their needs.

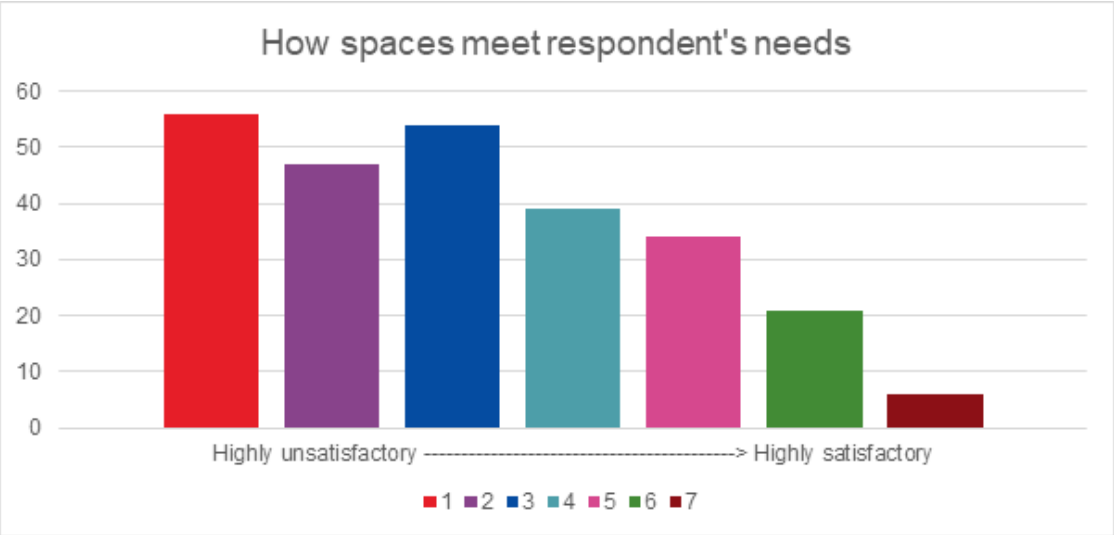


Figure 29. Respondent satisfaction with how spaces meet their needs.

55% of respondents had previously requested changes or adaptations to help them use spaces. 75% of respondents were highly unsatisfied or unsatisfied with how their requests for adaptations were responded to (see Figure 30).

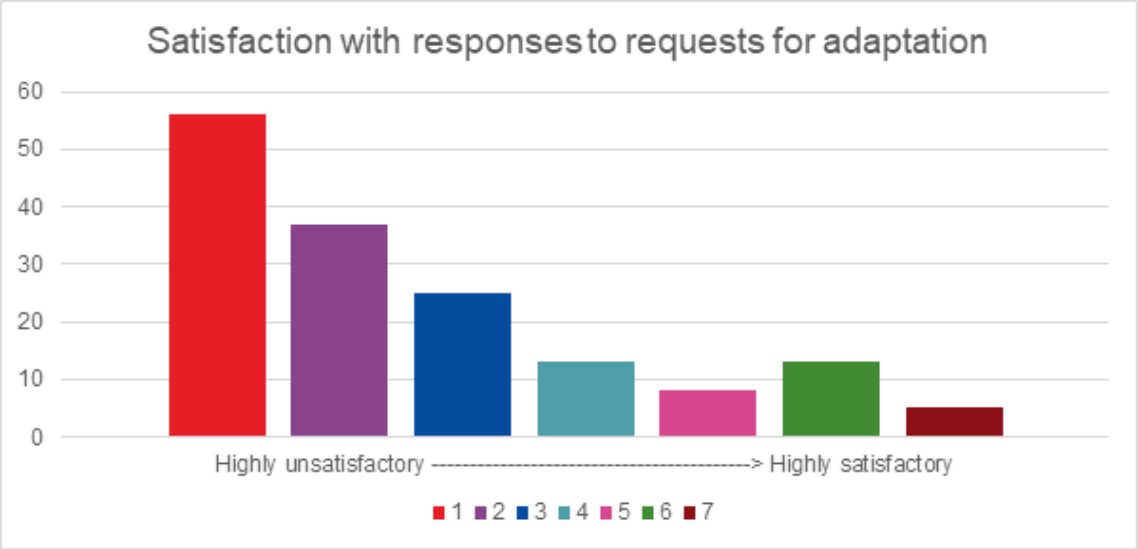


Figure 30. Respondent satisfaction with requests for adaptation.

8.5.2 Meeting needs

158 respondents provided an answer when asked to comment on how spaces meet their need. Table 36 shows the most common themes in long-answer responses.

Table 36. Most common themes in long-answer responses.

Theme	Percentage of answers
Barriers to wheelchair users	33%
General inaccessibility and non-compliance with standards	32%
Environmental or sensory conditions	23%
Need for specific facilities	18%
Time and effort tax	13%

Common themes (direct quotes are provided in **bold**):

1. Barriers to wheelchair users: 33% of responses
   - **"Try getting inside a disabled toilet with a wheelchair."**
   - **"Just really hard to go out and do normal things as a wheelchair user, very limited on where we can go."**

The most identified barriers to wheelchair users were a lack of space to manoeuvre (10% of responses), most frequently in relation to lifts and sanitary facilities, a lack of accessible sanitary facilities or issues with their design (14% of responses), and a lack of step-free access (13% of responses).

2. General inaccessibility and non-compliance with standards: 32% of responses
   - **"I'm faced with multiple barriers in every building."**
   - **"I can't access many restaurants, shops, hotels or pubs because of the lack of level access. Most places I try to go to do not meet my needs."**

A common theme throughout many responses was the impression that spaces in general were not accessible, and that many places did not meet minimum standards or respondent's needs.

3. Environmental or sensory conditions: 23% of responses
   - **"Too hot. Too bright. Too noisy. Not enough seating."**
   - **"Spaces don't seem to be designed with deaf and hard-of-hearing people or autistic people in mind. […] Particularly bad is artificial lighting - flickering, humming, being too intense. This is both in public places and work settings. Or places which have the radio on to a station with talk - it is very difficult to hear over, and awkward to ask people to turn it off or change the station because it is on a triggering subject."**

Many respondents listed environmental conditions – heat, noise, light – as a barrier.

4. Need for specific facilities: 18% of responses

- **“If there isn’t a Changing Places at a venue I cannot attend that venue, it’s as simple as that.”**
- **“I'd like to see more contrasted text when needed, and larger print where it can be done.”**

Respondents identified specific facilities that were beneficial or necessary to allow them to access a space. The most identified specific facility was seating or rest areas, mentioned in 9% of answers.

5. Time and effort tax: 13% of responses

- **“Finding information on what is and isn't available is a continuous task that takes time, every time you leave the house.”**
- **“Disabled people’s needs are an afterthought. As well as inaccessibility making daily life difficult, we are made to feel more excluded by things like having to walk further for a lift/ramp, take a back entrance into a building via the goods lift etc.”**

Many respondents identified that, because of their disability or condition, additional time and work were required to access and use the built environment, beyond what would be required of a non-disabled person. This included effort to find out what accessibility accommodations were available in advance, extensive planning required for everyday activities and trips, and the difficulty or frustration associated with communicating their needs to the building or service provider.

8.5.3 Requests for adaptation

120 respondents provided an answer when asked to comment on their experience of requesting changes or adaptations. Table 37 shows the most common themes in long-answer responses.

Table 37. Most common themes in long-answer responses.

Theme	Percentage of answers
Requests for changes denied or ignored	42%
Lack of understanding, empathy, or care	22%
Difficulty achieving adaptations	19%
‘You are the problem’	12%
Positive experiences	9%

Common themes (direct quotes are provided in **bold**):

1. Requests for changes denied or ignored: 42% of responses
   - **“Nothing at all was done.”**
   - **“Recommendations are usually ignored or end up being watered down.”**

Respondents reported being denied or ignored when requesting changes. Many respondents referenced ‘lip service’ or excuses – a general sense that needs were not appreciated, and people were unwilling to make adjustments.

2. Lack of understanding, empathy, or care: 22% of responses
   - **“Complaining and reporting gets me nowhere […] I have had to raise complaints with them all and nothing changes. They literally do not care.”**
   - **“The requests are seen as 'Low Priority' with a completion date of at least 10 or more years.”**
   - **“I offered to show them exactly what the problems were, but they refused the offer and had no understanding whatsoever of what makes something accessible. No one actually was trained in accessibility issues in the organisation and therefore some remote manager threw money at the problem and made it even worse!”**

Many responses included the impression of being ‘brushed off’, of people not caring sufficiently about their needs, or a general lack of understanding and awareness of disability. These included responses reporting that their needs were not appreciated / believed in, for example because they have an ‘invisible’ disability.

3. Difficulty achieving adaptations: 19% of responses
   - **“Changes are often perceived as an unnecessary expense.”**
   - **“People always try and be helpful but sometimes shop layouts and number of people make it difficult.”**
   - **“Some changes are too expensive and difficult. For instance to change a lift would be costly. To install visual entry systems to buildings is costly.**

Barriers to achieving adaptations, whether due to cost or the difficulty of adapting existing buildings were also frequently identified. The most frequently reported request for adaptation was in relation to workspace. **9% of respondents** referred to requests for adaptation either in office spaces or with office equipment (desks, chairs etc.).

4. ‘You are the problem’: 12% of responses
   - **“You’re often made to feel “difficult” or troublesome.”**

- **“Space designers and operators generally don’t see the importance of proactive accessibility and inclusive design, or the harm caused by bad design. I feel like a difficult troublemaker when I say it.”**

Responses reported feeling that the person requesting the adaptation was seen to be the issue, or to be causing a problem.

5. Positive experiences: 9% of responses

- **“Most times people are willing to help make small adjustments.”**
- **“At work I received a better office chair to afford me a comfortable seated position.”**

Some respondents found that their requests for changes were, either in all or most cases, successful and met with understanding.

8.5.4 Changes to behaviour

125 respondents provided an answer when asked to comment on changes they had made to their behaviour in the past week to accommodate their access needs. Table 38 shows the most common themes in long-answer responses.

Table 38. Most common themes in long-answer responses.

Theme	Percentage of answers
Inability to participate fully	54%
Time and effort tax	38%
Lack of provision to meet needs	25%
Staying home	24%
Compromise to safety, security or comfort	18%

Common themes (direct quotes are provided in **bold**):

1. Inability to participate fully: 54% of responses

- **“Couldn't park car outside a restaurant so had to drive on and find another venue.”**
- **“All the time we can't do normal things because nothing is accessible. Every day is planned around the limited things we can access.”**

54% of respondents described being unable to participate in an activity or visit a particular place or space in the past week.

2. Time and effort tax: 38% of responses

- **“Could not use my wheelchair to access building, could not use wheeled walker down hallways, had to take multiple aids and an assistant.”**

- **“Had to go to different station which involved extra bus journey to avoid long walk to lifts at interchange.”**

38% of answers indicated respondents had expended extra effort or cost because of access barriers. Frequently this was in relation to travel and transport – for example, taking private vehicles instead of public transport or taking longer or more complicated routes.

3. Lack of provision to meet needs: 25% of responses

- **“Changed plans and shortened visits due to lack of accessible toilet facilities.”**
- **“Doctor's surgery provided only a voice phone number to make an appointment. I had to walk to the surgery to make the appointment. I fear I won't always be able to do that.”**
- **“We didn't manage to do a whole day at the zoo as planned as there were not enough seating areas or toilets along the route […] all the information to get around was unreadable for someone with a vision impairment.”**

25% of answers identified specific lack of provision of facilities or features that prevented access or presented a barrier to access. Most identified features were:

- Lack of step-free access, including lifts (8% of answers)
- Lack of accessible sanitary facilities (8% of answers)
- Lack of parking (7% of answers)

4. Staying home: 24% of responses

- **“I stayed at home.”**
- **“I stay at home a lot. I don't stay in hotels or book holidays mainly because of accessibility issues.”**
- **“Gave up and returned home.”**

24% of respondents indicated that they were unable to leave home, chose to stay at home, or did not participate in activities out of their home in the past week. This indicates that, for many disabled people, access barriers present a serious obstacle to participation in everyday life.

5. Compromise to safety, security or comfort: 18% of responses

- **“I had to empty my catheter bag outside down a drain because a venue didn’t have disabled toilet facilities.”**
- **“Having to have my disabilities negatively affected in order to access places that weren't disability friendly.”**

- **“Changes made to where I could walk my guide dog, so having people shout at me.”**

18% of respondents gave answers indicating that they had visited a place with access barriers, but that their safety, security, wellbeing or comfort had been compromised as a result. This included experiencing pain / negative health effects and a loss of hygiene or dignity because of a lack of sanitary or changing facilities.

8.6 Summary and key findings

The purpose of the qualitative survey was to understand the views, experiences, barriers and helpful features for a wide range of disabled people and people with long-term health conditions in non-residential environments in England.

Key findings included:

Demographics

- A high prevalence of co-occurrence across multiple conditions and disabilities – 65% of respondents reported in more than one disability category. This indicates that many people have multiple and complex needs, and that disabilities frequently coincide with experiences of fatigue, pain, mental health conditions and health issues generally.
- 45% of all respondents reported using more than one mobility aid and 57% of wheelchair users also reported using an ambulant mobility aid. This indicates that mobility aid use is difficult to generalise and will vary even with one individual.
- More than 50% of respondents reported requiring assistance to carry out everyday tasks. This included formal and informal care. Most people who needed assistance were mobility aid users – around 64% of non-mobility aid users did **not** require assistance, as opposed to 17% of mobility aid users.
- Age / disability overlaps were largely as expected, with older respondents more likely to report dexterity, hearing and mobility conditions, and younger respondents more likely to report mobility, cognitive / learning and neurodiversity conditions than the average response. Working age respondents (18-64 years old) were more likely to report mental health conditions. This is largely consistent with the findings of the Objective 1 research.

Barriers and helpful features

- 93% of all respondents reported experiencing a barrier or making a change to their behaviour. 79% of all survey respondents reported experiencing a barrier to circulation.
- The largest respondent group was people with mobility-related conditions, who reported barriers due to doors, obstacles to horizontal circulation, and stepped and step-free access. 93% of people in this group reported stairs as a barrier and lifts as helpful.
- For non-mobility related categories, environmental conditions appear to have the greatest impact – including lighting, sound, and visual appearance of surfaces. The most identified barrier for all survey respondents was loud background noise when trying to communicate (52% of all survey respondents) and the most identified helpful feature was natural light (40% of all survey respondents).

- In many cases, the survey findings validated what would be expected according to current access and inclusive design guidance. For example, it is not surprising that a vast majority of respondents in the mobility group identified stairs as a barrier and lifts as a helpful feature. However, the data collected helps to give some idea of the scale and impact of particular barriers and helpful features.
- In other cases, the survey indicated unexpected results, results that run counter to commonly accepted accessible design principles, or new data which may not previously have been identified or collected. For example, it may be unexpected that more people in the mobility group generally seemed to prefer a peninsular layout (extra space to both sides of a toilet pan) to a corner layout in accessible WCs. Given the small sample size, this survey data does not represent a sufficient data source, on its own, to indicate a need to alter guidance. However, further research and study is recommended to delve into the issues and understand better how people experience the built environment.

Views and experiences

- Consistent themes were identified which give some insight into the principal barriers and experiences faced by disabled people.
- The built environment is, in general, not meeting the needs of disabled people and people with long-term health conditions. More than 50% of respondents described it as ‘highly unsatisfactory’. Less than 10% described it as ‘highly satisfactory’.
- The inaccessibility of the built environment presents a serious barrier to many disabled people to participate fully in life. Many respondents reported an inability to participate and use many spaces, or a sacrifice to health, safety or comfort in order to use inaccessible spaces. 30 survey respondents (more than 10% of the total survey respondents) reported that they had not been able to participate in an activity outside their home in the past week and 54% of long-answer responses described a situation where the respondent was unable to participate fully in an activity in the past week.

9. Research Stream 6: Residential interviews

The qualitative interviews aimed to understand the views and experiences of a wide range of disabled people and people with long-term health conditions about their personal dwellings in England.

The research consisted of structured interviews with a range of disabled people and mobility aid users in England to collect in-depth qualitative data about barriers encountered in people's dwellings, as well as to identify specific adaptations and good practice design examples that characterise specific disabilities.

44 disabled participants were interviewed by professional Occupational Therapists from The Occupational Therapy Service (TOTS) between November 2021 and March 2022. Interviews were carried out either in the participant's own dwelling or via telephone interview.

Interviewers also had the opportunity to make additional notes and observations about what adaptations had been made in the dwelling – for example, observing and recording location of grab rails.

Responses cut across disability and health condition categories and across a range of demographic groups. Respondents used a variety of mobility aids and assistive devices.

See Section B.1 in Appendix B for the interview questions and structure.

9.1 Demographic categories

9.1.1 Age

Interviewees belonged to a range of different age groups from children to older adults (see Figure 31). Fewest respondents were in the 0-18 years age group. This represents a data gap in the experiences and needs of disabled children in their homes.

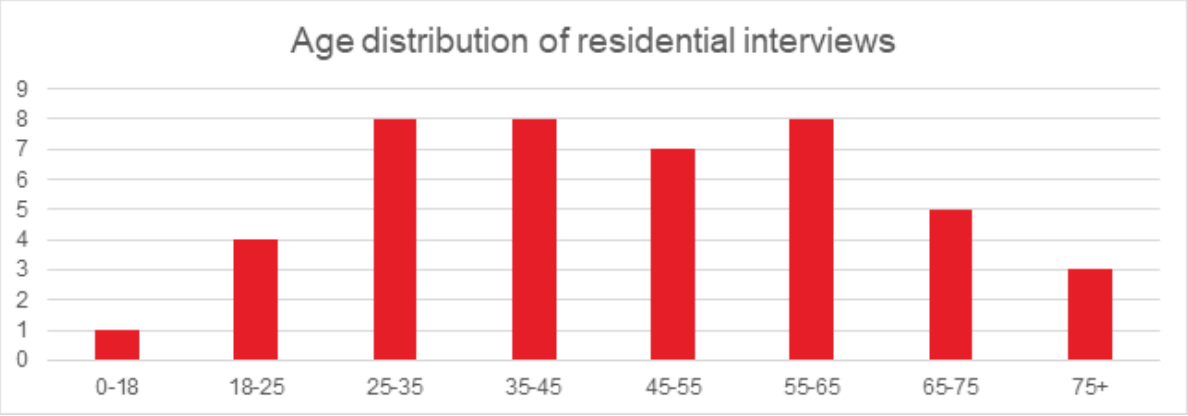


Figure 31. Age distribution of residential interviewees.

9.1.2 Sex and gender

66% of interviewees were female, and 34% were male. None of the interviewees identified as transgender or non-binary.

9.1.3 Ethnic group

Interviewees were selected to cover a range of ethnic groups to provide a representative sample (see Figure 32). 63% of the sample were White, 4.5% were Mixed / Multiple, 23% were Asian or Asian British, and 9% were Black, Black British, Caribbean or African[35].

Figure 32. Ethnicity group distribution of residential interviewees.

9.1.4 Disability

Most interviewees had mobility-related conditions, as this is the category most relevant both to the work of TOTS and to the need for adaptation / alteration within the home. However, a wide range of disabilities and long-term conditions were represented (see Figure 33).

[35] Compared to ethnicity rates in the population for England (see 2011 Census data in Section 8.1), this is an overrepresentation of all groups except White and 'Other' – however, it was not considered necessary to address this overrepresentation in this research as it was deemed more valuable to hear the views of often under-represented groups. These ethnic groups were also underrepresented in other similar aspects of this project, such as amongst survey respondents.

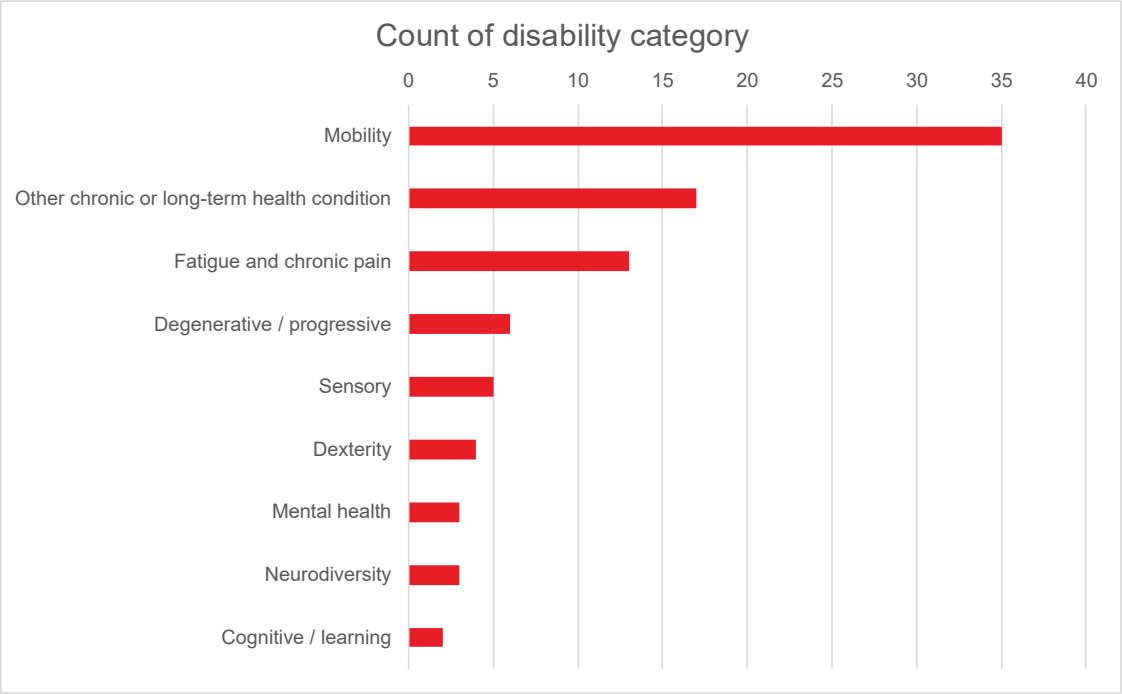


Figure 33. Disability category distribution of residential interviewees[36].

9.1.5 Mobility aid use

Figure 34 sets out the distribution of mobility aid types, including hoists and accessible vehicles (defined as Motability vehicles of any kind, including wheelchair-accessible and non-wheelchair accessible).

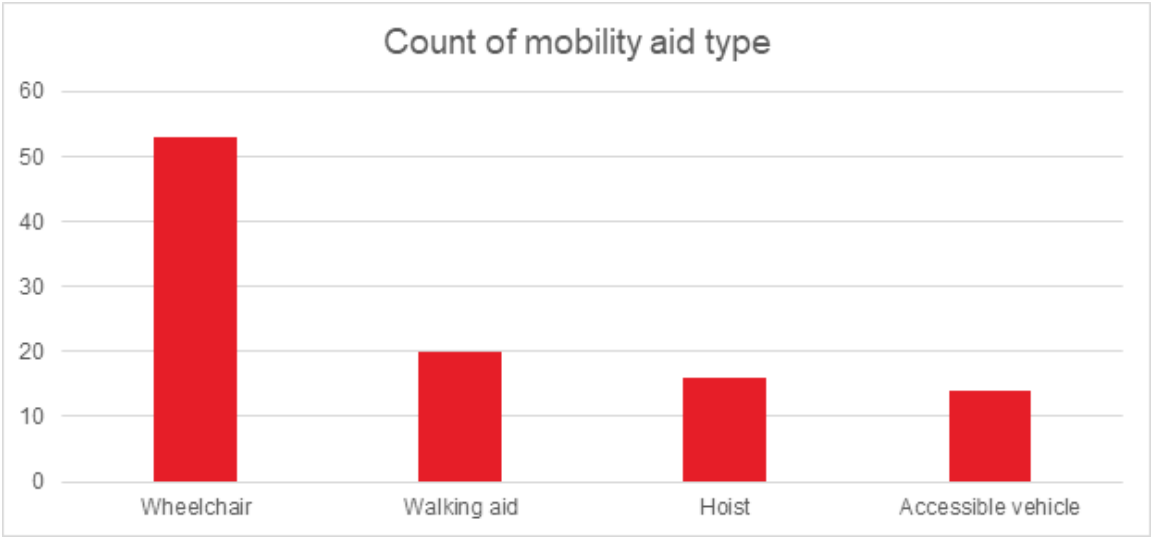


Figure 34. Mobility aid use by residential interviewees.

A wide range of mobility aid uses were covered by the study, including a range of different wheelchair types and walking aids. Most interviewees were wheelchair users. The count of

[36] 'Sensory' disabilities included both vison and hearing disabilities.

mobility aids is higher than the overall sample as most participants use more than one wheelchair or mobility aid type.

The aim for this item was not to achieve a representative sample of different mobility aids, as the research is particularly interested on the design of dwellings for disabled people in general, including people with mobility aids. As such the current sample is considered consistent with these research goals.

9.1.6 Physical characteristics

32.5% of participants had a larger body size / were obese. Often this was reported as being related to mobility / immobility issues.

4 participants had a temporary injury affecting movement.

1 participant was pregnant.

9.1.7 Dwelling types and tenure

Interviewees reported a range of dwelling types (see Figure 35).

64% of participants were owner occupiers, 18% were Housing Association properties, 9% Council owned, 2% private rent and 7% in other types, including annexes to family members and temporary accommodation. One participant was temporarily housed in a bed and breakfast (B&B).

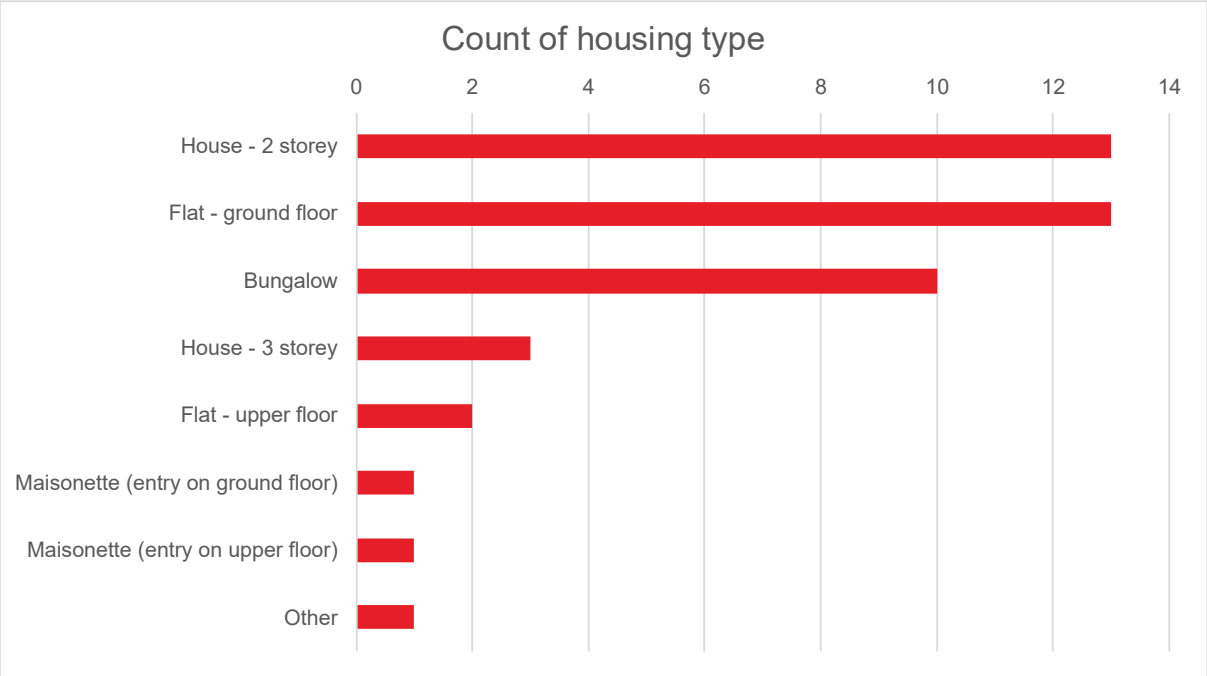


Figure 35. Housing type of residential interviewees[37].

9.1.8 Dwelling adaptations

Participants were asked if they were aware if their housing had been designed to meet a specific access standard. This was asked to see if there are any clear patterns in issues with particular standards.

57% of interviewees reported their dwelling had not been designed to meet a specific access standard. However:

- 11% of dwellings had been designed to wheelchair housing standards (including the Wheelchair Housing Design Guide[xlvi]),
- 9% of dwellings had been designed to 'Lifetime Homes' standards[xlvii]
- 2% had been designed to Approved Document M, Volume 1. Of these:
- 32% had been designed to M4(2) Category 2: Accessible and adaptable dwellings
- 2% to M4(1) Category 1: Visitable dwellings
- 0% to M4(3) Category 3; Wheelchair user dwellings.

5 interviewees were not aware if their dwelling had been designed to an accessibility standard.

90% of interviewees indicated that changes had been made to their dwelling. Of these, 48% of interviewees had funded their adaptations, 33% had been funded by the Local Authority,13% through joint funding, such as Disabled Facilities Grant and charities, and 6% through legal settlements.

[37] 'Maisonette' is used to describe flats on more than one floor.

Details of adaptations / alterations were provided by 40% of the interviewees. Of these the most common alterations recorded were for bathrooms (53%), 35% had installed ramps or other alterations to provide level access, 24% had widened doors, 18% had added an extension and 18% had added handrails (see Figure 36).

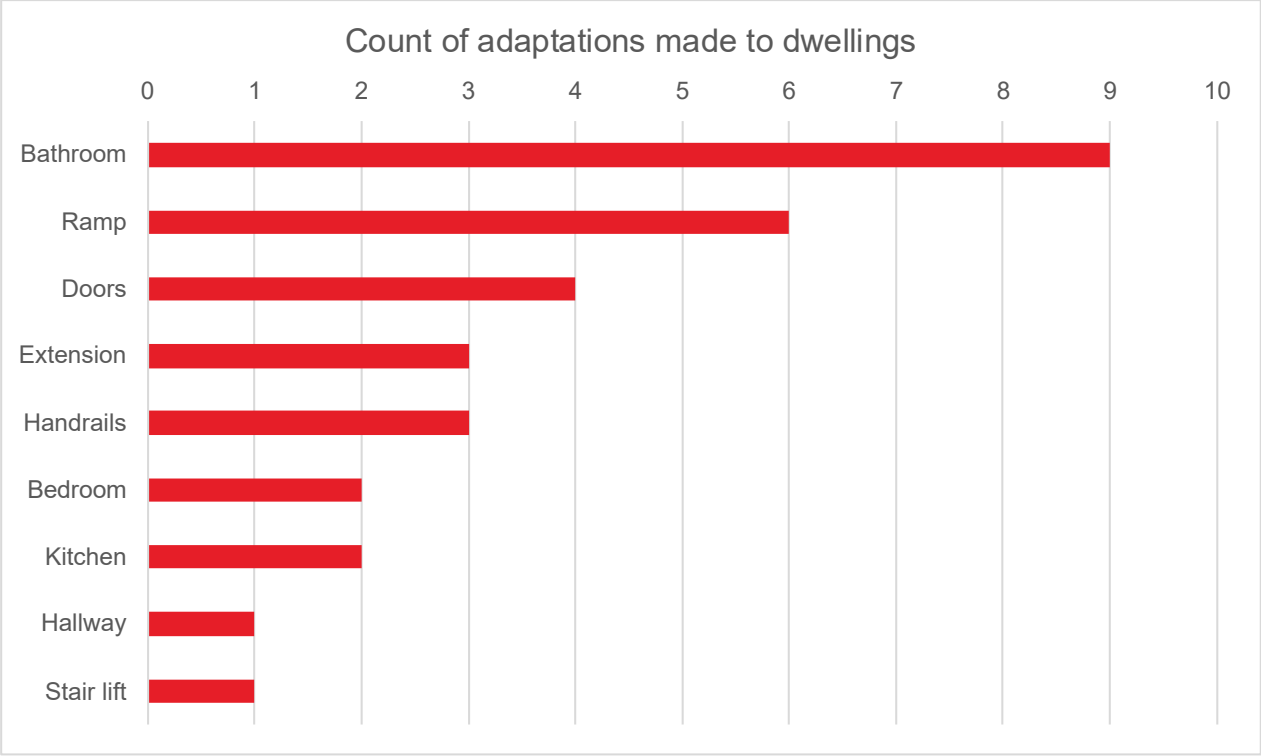


Figure 36. Adaptations made to dwellings by residential interviewees

9.1.9 Barriers and helpful features

In considering the findings, it should be noted that many interviewees reported using several types of mobility aid, so some interviewees may belong to more than one category (e.g. both a walking aid and wheeled mobility aid user). Similarly, many interviewees reported a co-occurrence of disability, so may belong to more than one disability category.

- Entry
  - 64% of interviewees reported barriers to entering and leaving their dwelling. Of the interviewees who reported they used mobility aids, those who used walking aids (i.e. walking frames, walking sticks and crutches) were most likely to report entry-related barriers (80% of applicable interviewees), followed by wheeled mobility aid users (i.e. powered, self-propelled, attendant-propelled and all-terrain wheelchairs) (68% of applicable interviewees).
  - In detail, 61% of interviewees reported that the approach to the door from the street was a barrier, with 64% reporting that step-free access would be helpful to overcome this, and 54% reporting that a level threshold would be beneficial.
  - Interviewees resident in 2-3 storey houses or upper floor flats were mostly likely to report barriers to entering and leaving their dwelling (81% and 75% of applicable interviewees respectively).

- 59% of interviewees reported the weight of the door was a barrier, and 52% reported pushing the door was a barrier. A lightweight or power-open door (68%), and an automated door (61%) were reported as being helpful. This is notable in a residential setting, where automated doors would rarely be provided except occasionally at communal entrances.
- 65% of interviewees reported that the force required to turn the door lock was a barrier, with 71% stating that an automated lock or key fob would be helpful.

- Letters and post
  - 66% of interviewees reported picking up letters as a barrier, with 54% reporting that a letter catcher would be helpful. For 36% of interviewees, it was the height of the letter box from the outside that presented a barrier.
  - Of interviewees that reported they used mobility aids, 53% of wheeled mobility aid users reported picking up letters as barrier, followed by 40% of walking aid users.
- Circulation
  - Narrow routes and corridors were reported as a barrier by 77% of interviewees, with wider routes reported as helpful to the same degree. In long-answer responses, some interviewees identified not being able to access some rooms in their house (e.g. a second bedroom) due to small spaces for internal circulation.
  - Of interviewees that reported they used mobility aids, 65% of walking aid users reported narrow routes and corridors as a barrier, followed by 58% of wheeled mobility aid users.
  - 96% of interviewees reported stairs as a barrier, with 68% unable to use stairs entirely. 78% reported lifts as helpful to overcome this.
  - By disability category, 64% of interviewees with a long-term or chronic health condition reported they were unable to use stairs, and 45% of interviewees with a mobility-related disability.
  - Interviewees resident in 2-3 storey houses or upper floor flats were mostly likely to report barriers to moving around both on one floor (81% and 75% of applicable interviewees respectively) and between floors (75% of applicable interviewees respectively).
  - In long-answer responses, some interviewees identified handrails / a lack of handrails as the barrier to stair use, while others identified that they were unable to install a lift and would prefer a single-level home.
- Escape
  - 75% of interviewees reported needing assistance to evacuate their home as a barrier.
  - By disability categories, 48% of interviewees with a mobility-related disability reported this as a barrier (increasing to 61% when including interviewees who raised not being able to take their mobility aid with them when evacuating as a barrier).

- Interviewees resident in 2-3 storey houses were also mostly likely to report barriers to emergency evacuation (81% of applicable interviewees respectively).
- More interviewees resident in ground floor flats reported barriers to emergency evacuation than interviewees resident in upper floor flats (69% to 25% of applicable interviewees respectively). This suggests variation in experience for disabled people living in shared residential environments (e.g. in a block of flats). While 62% of interviewees resident in ground floor flats stated that their dwelling had been designed to a specific access standard, these findings suggest that the wider residential environment (e.g. communal areas in a block of flats) may not be particularly accessible.

- Kitchens
  - The most reported barrier in kitchens was carrying food and drink, with 71% of interviewees reporting this as an issue.
  - Of interviewees that reported they used mobility aids, 51% of wheeled mobility aid users reported narrow routes and corridors as a barrier, followed by 40% of walking aid users.
  - In the physical environment, space to turn around was the biggest barrier (65%), followed by a lack of knee space beneath kitchen counters (61%).
  - In long-answer responses, 4 interviewees reported being unable entirely to access or use their kitchen.
  - For eating purposes, interviewees reported that more space to access a table and a height-adjustable table would be helpful.
- Bedrooms
  - The biggest barrier in bedrooms was a lack of space to move and turn next to the bed (76%), followed by space beside the door (68%). 60% of interviewees reported having access to one side of their bed only. 60% reported not having enough space to get to the window in their bedroom.
  - More space next to the bed was the preferred option, with 88% of interviewees requesting it. More space in general, to reach the window, for storage and for mobility equipment, were identified as being helpful by 75% of interviewees.
  - 24% of interviewees stated that hoisting facilities, or a different type of hoisting facility to those they currently had, would be helpful.
- Bathrooms
  - The most reported barrier in residential bathrooms was space, with 66% reporting not enough space to use facilities independently, and 45% reporting there was not enough space for their assistant / helper.
  - Of interviewees that reported they used mobility aids, 60% of walking aid users reported barriers using the toilet due to a lack of space (whether independently or assisted), followed by 54% of hoist users and 47% of wheeled mobility aid users.
  - 38% of interviewees reported the height of their toilet as a barrier.

- 76% of interviewees reported not having sufficient space in front of their basin, or not being able to reach / use their basin.
- 55% of interviewees reported that a level access shower was helpful, and 45% a wet room.
- 54% of interviewees specifically reported preferring not to use a bath; for those who did use baths, 32% had trouble getting out of the bath. A range of different helpful features were reported: 4 people requested grab rails, 2 requested a bath seat, 2 a slip-resistant mat, 2 more space beside the bath.

- Other features
  - 69% of interviewees reporting having insufficient space to store more than one mobility aid. 56% reported a barrier due to a lack of electrical outlets in the storage area. 88% reported that having more than one storage space for mobility aids would be helpful.
  - 27% of interviewees reported issues using outlets, most commonly relating to the use of outlets and switches at floor-level.
  - 9% of interviewees reported not being able to reach thermostats, boilers or temperature controls in their home.
  - 18% of interviewees reported having a sensitivity to temperature, with 16% reporting their home was too cold.

9.2 Summary and key findings

The qualitative interviews aimed to understand the views and experiences of a wide range of disabled people and people with long-term health conditions about their personal dwellings in England. The interviews also aimed to identify barriers, as well as any adaptations and good practice examples, that characterise specific disabilities or long-term health conditions.

Most participants had mobility-related disabilities or long-term health conditions; however, a wide range of disabilities and long-term conditions were represented in the sample. Participants used a wide range of mobility aids, including a range of different wheelchair types and walking aids.

Most participants lived in a dwelling not designed to any specific access standards (e.g. ADM, Lifetime Homes Standards etc.), but most had made some form of adaptation to their dwelling in relation to their access needs.

The most common adaptations were in bathrooms; followed by adaptation to provide level access or wider spaces.

Several common barriers were identified by interviewees; these included:

- Entry and leaving their dwelling, in particular a lack of step-free access, and the weight and operation of doors.
- Narrow circulation routes.
- Using stairs. Most interviews were unable to use stairs at all.

- Needing assistance to escape.
- Specific dwelling features:
  - Kitchens, in particular carrying food and drink, a lack of turning space and knee recesses)
  - Bedrooms, in particular a lack of space for turning and circulation and a lack of storage.
  - Bathrooms, in particular a lack of space for turning and assistants, height of sanitaryware, and a lack of level access.

Other barriers included a lack of storage for mobility aids, height of switches and controls and poor environmental conditions (i.e. dwelling too cold).

However, the types and severity of barriers, as well as the helpful features identified, showed some variation depending on the respondent's accessibility requirements, their dwelling type and the type of mobility aid they used.

10. Research Stream 7: Focus groups

The focus groups aimed to gain in-depth insight into the views and experiences of specific groups of disabled people and people with long-term health conditions about the built environment in England.

The focus groups were selected to investigate specific areas or issues in more detail. Therefore, the following groups were invited to participate:

- Neurodivergent people (see Section 10.1.1).
- People with chronic and long-term health conditions (see Section 10.1.2).
- Wheelchair users (see Section 10.1.3).
- Changing Places users (see Section 10.1.4).
- People with children (see Section 10.1.5).
- D/deaf and hard of hearing people[38] (see Section 10.1.6).
- Blind and partially sighted people (see Section 10.1.7).

All attendees were people with lived experience of the relevant group they were in; many were also involved in accessibility work or advocacy more widely as well (for example, members of Access Panels, disability advocates).

The focus groups were held between March and May 2022 and a total of 33 people participated across the 7 groups. The focus groups were conducted online via Microsoft Teams.

The approach for the focus groups was to facilitate an open discussion between participants around the following questions:

6. What is the most common barrier you experience in places and spaces?
7. What design or feature is most helpful to you to make spaces accessible and usable?
8. Do you have a good example of a place that accommodated your needs well?

Key findings from each focus group are provided in this section of the report.

[38] Deaf with a capital D refers to a person with profound hearing loss (i.e. close to, or no functional hearing). It is also used to describe people who are active members of the Deaf community and identify themselves as culturally Deaf. The 'lowercase d' deaf refers to the medical definition for hearing loss that may differ in severity by individual. People who are deaf may not identify themselves with the Deaf community or culture. They may also not use sign language as a means of communication and prefer to rely more on oral communication. Hard of hearing refers to a person with mild to moderate hearing loss.

10.1.1 Focus group: neurodivergent people

A focus group for neurodivergent people was held to understand better what the challenges and opportunities are relating to the built environment. Four participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 39. Common barriers and helpful features in places and spaces for neurodivergent people.

Category	Barriers	Helpful features
Spatial	• Space to move around furniture. • Pressures on time (e.g. automatic activation of entrances, doors not staying open long enough, taps / showers that switch off automatically). • Revolving doors. • Size of lifts (too small to accommodate more than one person), and speed of lifts causing vertigo. • Vertigo – being near a window. • Lack of seating.	• Handrails to provide something for people to hold onto as they navigate. • Clear sightlines to allow someone to see a space / see the exit points, and to navigate easily, free of obstructions. • More seating along the route to allow someone to pause.
Environmental	• Loud or unexpected sounds (in particular, automatic hand driers, and public announcements were noted). – **"I don't cope well with the sound of babies crying… music (horrible radio stations), and I don't get on well when there are loud noises, like building works."** • Echoing spaces. – **"Echoey noise… feels like being in a swimming pool; the noise domes, and I feel like my brain starts to shut down; I am concentrating so hard to concentrate on what I am doing next."** • Fluorescent lights. • Busy patterns. • Tactile interfaces – e.g. texture of materials. • Access to ventilation / air conditioning that does not compromise other requirements, e.g. needing to be away from a window to avoid feelings of vertigo.	• Control of temperature - this was mentioned in relation to water temperature for showers, as well as room temperature to make sure that people did not feel **"closed in".** • The option to sit away from windows was also noted (e.g. for people experiencing vertigo or distracted by noise when windows are open).
Interface	• Crowding. • Pressure to move out of the way for other people, or anxieties over needing to interact with other people.	• 'Meet and greet' systems to help people with additional needs in busy places. – **"For example, in a space I was in a couple of years ago, someone met you at the door – how wonderful would that be if there was a 'meeter and greeter' you could book that could help you along the way?"**
Wayfinding and navigation	• Clear wayfinding making it obvious where exit routes are; floor-based navigation systems / coloured lines were also reported as helpful. – **"I find it difficult to go into spaces where I can't see a way out… in …you have to go all the way round, and it scared me."**	• Lines on the floor to help navigation (instead of board signage) (i.e. that someone can follow to the destination). • An attendee noted that highlighting different routes in the building that may be quieter (e.g. not subject to unpredictable noise, etc.) would be useful. • Maps to show where particular features are, including seating.

In addition to the physical features noted in Table 39, the group expressed the importance of Access Statements for buildings to communicate the provisions that are available. They also referred to the anxiety that is caused when people are asked to 'prove' their disability; a desire was expressed to have systems in place (e.g. a 'passport') to simplify this.

Key quotes from the discussion:

- **"Maybe there is a way of distinguishing spaces that are okay spaces for everybody, and for people who have problems with other stuff."**
- **"Because I don't have that label, the staff think I am being awkward."**

- **“Issues that aren’t always considered – entrances, doors that are on time limited, open for a certain amount of time; this should be adjustable. Same with lifts.”**
- In access forums: **“people talk about level access but people don’t consider the specific issues around senses and time, around neurodivergent. Lots of neurodivergent people won’t think to put this down.”**

Good practice examples:

The group was unable to identify any particular spaces in the UK that demonstrated good practice that accommodated their needs well, but noted some international (Lisbon, Barcelona, France) locations, and reminisced of a time in UK history when the provision of regular seating was noted as not only a useful feature to accommodate opportunity for rest and quiet, but also to encourage integration and community. There was also a comment on the benefits that assistance (e.g. ‘meet and greet’ personnel) could bring to help ease anxiety when navigating through the built environment.

10.1.2 Focus group: people with chronic and long-term health conditions

A focus group for people with chronic and long-term health conditions was held to understand better what the challenges and opportunities are relating to the built environment. Seven participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 40. Common barriers and helpful features in places and spaces for people with chronic and long-term health conditions.

Category	Barriers	Helpful features
Spatial	• Restrictions on available routes to suit requirements (e.g. lack of dropped kerbs). • Long travel distances and / or lack of suitable seating. • Lack of step-free access and well-designed ramps. • Spaces being obstructed – e.g. by parked cars, bins, etc. • Provision of suitable facilities for the population (and not just treating accessibility as a tick-box exercise). • Lack of stable ground. • Lack of space to allow movement of others around (e.g. on a stair during evacuation). • Lack of accessible toilets. • Heavy doors and lack of automation, including certain door types / closers are needed for fire safety purposes. • Historic spaces which do not accommodate access features. • Patterned floors (creating strobing effect).	• Provision of automatic sliding doors. • Provision of accessible toilets. • Allowing doors to swing in both directions. • Making sure that controls etc. are at an accessible height and location. • Consistent and regular provision of dropped kerbs. • Minimising travel distance, and, as a minimum, provision of regular seating, including some with arm rests. • Appropriate location of lifts (regarding travel distance, legibility (to avoid **"treasure hunt"** for the lift) and flow of other people). • Firm and level ground, without busy patterning, to allow stable footing. • Implied through the discussion, but not explicitly discussed in relation to solutions: - Keeping obstructions off circulation paths, including other facilities (e.g. parking) but also in relation to flow of other people too (e.g. stair and corridor width).
Training and awareness, and communication:	• Lack of / inconsistency in accurate reporting of accessible features (e.g. through an Access Statement) and communication of these. • Lack of equity in the experience (e.g. **"treasure hunt"** for lifts, segregated routes, back access, automatic doors being locked). • Lack of disability awareness training. • Being asked to repeat oneself (can be tiring). • Lack of conversation / collaboration with disabled people during the design process. • Maintenance and implementation of what has been provided as an access feature (e.g. not locking the automated door).	• Implied through the discussion, but not explicitly discussed in relation to solutions: – Options to facilitate conversation (e.g. to avoid people needing to repeat themselves).

In addition to the physical features noted in Table 40, the group expressed the importance of Access Statements to communicate the provisions that are available, as well as training for operators. Of note, one attendee commented about streamlining the operations (e.g. in rail services) to put the onus / responsibility of coordinating assistance when there are changes to the schedule on the operator and not the individual. The importance of consultation with disabled persons' groups was also raised during the discussion.

Key quotes from the discussion:

- **"Made to feel like it is your fault."**
- **"I was so anxious… don't want to do that again."**
- **"Build it in, don't bolt it on!"**
- **"Disjointed thinking between organisations is a problem."**

Good practice examples:

The following places were identified:

- Manhattan Island – the provision of dropped kerbs, and attitudes of bus drivers, was described as demonstrating good practice.
- A holiday cottage in Wales, where an Access Statement was provided to communicate the accessibility of the space to inform decisions prior to booking.
- The Forum (Norwich) - was described as being **“built with accessibility in mind”,** with step free access to all facilities, accessible toilets, and seats throughout (although it was noted that some seats have not been replaced post-pandemic).
- Westfield (Shepherds Bush) – was described as having accessible toilets and seating available.
- Institute of Mechanical Engineers, which despite historic status, has incorporated an innovative lifting solution. It was noted by the participant that these are, however, expensive, and so funding would need to be made to install these to prevent only the wealthier organisations being able to implement.
- Nijmegen in the Netherlands, who are making the entire rail network accessible: **“…rather than the station and train being two entities, thinking about this as one thing so that the flow works well.”**
- Transport for London offices at Palaestra House, which was noted as having automatic doors and accessible buttons, access via an accessible station / line, and noted that a Changing Places was also to be fitted (delayed due to the pandemic) - **“The building as a whole is a good example… what you would expect from a company that takes inclusion seriously.”**

10.1.3 Focus group: wheelchair users

A focus group for wheelchair users was held to understand better what the challenges and opportunities are relating to the built environment. Seven participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 41. Common barriers and helpful features in places and spaces for wheelchair users.

Category	Barriers	Helpful features
Entrance to building:	• Manual doors - **"The biggest single barrier is at the entrance to buildings if the doors are not automated."** • Location of door controls (e.g. too close to the door, requiring people to reverse away from door swing). • Direction of swing. • Lack of step free access. • Automatic doors not maintained (out of order). • Journey between car and building - **"Getting out your car and getting to the building is half the challenge."**	• Access at the front of a building or within reasonable distance to the front.
Doors	• Door width (particularly the replacement of wide doors with narrow doors during refurbishment was noted) - **"Our legs act as battering rams."** • Thresholds (not level).	• Automatic doors that slide sideways to open, as often seen with automatic glass doors. – **"[Automatic] Swing doors often break and are not repaired."**
Space	• Often a minimum space is used, assuming that a manual wheelchair is all the space that you need - **"If you are in a power chair you have a larger turning circle."**	
Accessible facilities within buildings:	• Tables in restaurants too low. • Hoists not provided. • Lifts difficult to operate alone, must have someone with you. • Space within buildings not suitable. • Having to venture further away to find accessible venues with lifts, or Changing Places toilets, as they are not being provided within local authority buildings and places like GP surgeries and hospitals.	
New buildings and refurbished buildings:	• Not being provided with access at entrances (e.g. steps to enter). • Steep ramps (**"45 degrees"**) ramps being provided. • Existing width of entrance removed; narrower entrances being provided. • Fire evacuation plans cause red tape for wheelchair users in places, as people are unwilling to let them use upper levels due to the need to provide evacuation plans or because expense deters companies from hiring disabled people or providing access.	• Space e.g. turning space for larger wheelchairs. • Utilise a wheelchair user in design and consultation process. • The use of colour for wayfinding, and directional floor signage. • Participants reported it was easy to tell when a building had been designed thoughtfully and in consultation with disabled users.
Access paths	• Missing dropped kerbs. • Tactile paving creating a barrier for wheelchairs. – **"A sensitive design can make both items [kerbs and tactile paving] work. The last thing we want is one disabled group going against another disabled group."** • Fatigue due to long travel distances, particularly when surfaces are rough/soft and there are graded routes - "**Manual chairs are not as easy as people think, many people are thinking about getting power chairs."** – **"If you have been in a manual chair all your life you do have some upper body muscles, but it takes at least 10 years to build up the muscles."**	• Level streets with no kerbs (flush kerbs).

Category	Barriers	Helpful features
Outdoor and indoor surface materials:	• Pile height of carpet - thick plush carpet was noted as a barrier. • Cobblestones. • Paving being replaced by grass.	
Accessible WCs	• Thumb turn locks (small operating mechanisms being a barrier due to difficult hand operation for people with less dexterity), requiring people to leave doors unlocked and risk being exposed. • Automatic door closers being broken or making doors heavy and difficult to open.	• Rise and fall toilets were reported as helpful by one participant who had difficulty standing – **"I am using a power chair with a rising seat, so when using an accessible toilet I can't transfer from my chair to a toilet as I can't stand up. As I am on my own, I can't use a Changing Places."** • Touchless flushing. • Rigid tubing to the emergency pull cord (preventing it from being tied up). • Correct toilet height - some attendees found the toilet height in accessible WCs too low). • Wash and dry toilets.
Training and awareness, and communication	• Attitude from the public, that it is seen as big cost to provide access. • Being expected to know the building's accessibility prior to arriving. • Being unable to attend all social events as buildings are not accessible, which can feel excluding.	• Information on business and shop websites outlining their accessibility, as this reduces disappointment and time doing research to see if entering is possible in a wheelchair. – **"We shouldn't have to do 3 hours homework to visit a shop. We want to go to a shop and be able to turn up like anyone else can."**

Overall, discussions noted that buildings prioritise aesthetics over accessibility. Participants felt there was a disregard for Part M and accessibility requirements from Architects, Building Control and the Local Authority, and felt that there is currently no enforcement to have access for all.

Participants were frustrated by the lack of provision and the constant work required to identify and overcome access barriers. **"People are unable to take up work as they cannot access the building or floor within the building."** Participants reported feeling that the bare minimum, in terms of access, is being provided; and even then, it is not always right.

Good practice examples

The following places were identified:

- Roman baths in Bath: "**I was very impressed, they were very proactive, not everything was accessible, but they made 99% accessible."** The space was also reported as being well signed, staff well-trained, a platform lift was provided but with automatic door and buttons. "**Staff were educated and were very proactive which makes it much better when you have to go via a different route."**
- Sage concert venue in Gateshead: one participant reported that the venue has an Accessibility officer, it is also fully fitted with hoist and Changing Places toilets, and staff go over and above to accommodate needs, **"we were given a sound engineer's booth so we didn't disturb other people."**
- Newcastle and Gateshead: "**the Metro is getting better adding ramps on the doors, a really forward-thinking city looking at mobility."** One participant visited a tunnel under the Tyne which contained one side for cyclists and one for pedestrians and wheelchair users: **"an amazing experience, it is not perfect but showing the way to go."**
- Also in Newcastle: **"I managed to go on the beach in my power chair, as they added a path that takes you out on the beach, they looked at disability and enabled people access to go on the beach in wheelchairs. I loved it so much I went back again. There were also staff there so if you got into any difficulty, you could get help".**
- The Olympic Park was noted as being particularly accessible by one participant.
- It was suggested that everyone should write reviews for their area detailing accessibility experiences; Euan's Guide[xlviii] (a site allowing disabled people to provide reviews for others) was mentioned as a resource for this.

10.1.4 Focus group: Changing Places users

A focus group for Changing Places (CP) users was held to understand better what the challenges and opportunities are relating to the built environment. Four participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 42. Common barriers and helpful features in places and spaces for Changing Places users.

Category	Barriers	Helpful features
Availability and access	• Restricted opening hours, access should be 24 hours. • Not enough facilities provided in all locations. • Access, some require keys and therefore locating the person for access took time. • One attendee had used CP toilets at service stations and said they were **"a godsend"** for a variety of people going on holiday who knew that they did not need to search for CP toilets on route. However, attendees reported that more CP toilets were needed and should be provided in more facilities like sporting clubs, shopping centres and council buildings.	• Implementing showers in leisure centres to enable everyone to be able to shower after use.
Facilities	• Height of the facilities within the CP toilets not suitable for toddlers. • Functions of the CP toilets are not always accessible without the need for an assistant. • Safe and secure facilities are not always provided. • Information not displayed well (e.g. small print, placed too high).	• Changing pads and sanitary items to be provided within. • Ensuring all fixtures and fittings are installed at correct heights and locations. • With any installation for new items, ensure the noise of the machines is low. • Lighting within to not be obtrusive.
Maintenance	• Equipment maintenance (e.g. hoist not put on charge after use). • Cleaning and hygiene: not enough hygiene paper and no way of cleaning changing table; overall, the facility can be dirty, and responsibility for cleaning needs to be maintained.	

Discussion on ways to improve the CP toilets included the use of assistive technology to combat the barrier. Some participants explained they had been provided with a code from their local council to access CP toilets, however, they also explained that **"not everyone can use a mobile phone or code"** so solutions will need to be mindful of this. However, participants felt the use of QR codes to access CP toilets would provide the user with a level of respect and responsibility compared with Radar keys which are perceived as too accessible to the wider public (i.e. keys are available for purchase online).

Key quotes from the discussion:

- **"We need more of them and need them to be part of the landscape so we can just go and look for a toilet and find one that we can use."**
- **"There should be Changing Places toilets everywhere because they have lots of facilities in one place."**
- **"It is really interesting some people are coming on board and putting them in, but it comes down to when they are open."**

Good practice examples

The following places were identified:

- Sporting grounds.
- Theatres and concert halls.
- Council buildings and venues.
- Leisure facilities and gyms.
- Public areas of hotels.

- Service stations, it was noted to have the sat nav updated to indicate where they were provided or not.
- Transport hubs, airports, buses.
- Public health and medical facilities.
- 24-hour access in every town.

It was acknowledged that although there may be limited scope to alter existing buildings, ideally CP toilets would be installed in existing spaces too - **“Building Control can’t police existing buildings, but they should be implemented everywhere.”**

Final comments and discussions from the group were that **“you can’t go out of your house if we can’t go [to the toilet]”**: a normal life can only occur when facilities are provided everywhere with access provided 24-hours. While participants felt that some companies and places have started to implement CP facilities, this needs to be more widespread.

10.1.5 Focus group: people with children

A focus group for people with children was held to understand better what the challenges and opportunities are relating to the built environment. Four participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 43. Common barriers and helpful features in places and spaces for people with children.

Category	Barriers	Helpful features
Access and spatial	• Kerbs. – **"I am unable to go out without my children as they help to push me up the kerb".** • Ramps, particularly steep ramps to enter shops. • Access pathways that are too narrow or have obstructions along pathways. • Gates to playgrounds are heavy and difficult to open. • Access to playgrounds and play space in general is very limited, the equipment is not accessible for wheelchair user children or parents. • Layout of internal spaces does not allow for wheelchair users - one participant reported struggling to get to a table at a restaurant. • Schools (secondary education) are not being made accessible - participants felt that key decision makers are not always focused on accessibility. • Brand new buildings - fire escapes are still not being constructed correctly.	• Parking. – **"…the location, being 20 minutes away from your car when you are in a facility that does not have an accessible toilet, the size to ensure enough room is available to get in and out and an accessible path once out of the car."** • Flooring – smooth surfaces to move across for a wheelchair user. • Level access to both toilets and parking. • Automatic doors. • Acoustic attenuation in loud open spaces where echoing happens. • Providing visual contrast, as some contrast is too subtle.
Sanitary facilities	• Some places provide accessible toilets but not Changing Places toilets. • Waits for accessible toilets can be long, and sometimes the wheelchairs do not fit in the cubicle. • One participant uses a patient turner for their child; extra space is required to use this equipment that not all toilet facilities can accommodate. • A concern that one disability is prioritised over another: for example, the prioritisation of independent-use wheelchair-accessible toilets over Changing Places toilets.	• Providing accessible hand dryers that are not too loud, are not operated by motion-sensor and can be used by all (one attendee commented that hand dryers are "**The bane of our lives**"). • Provide papers towels. • Changing Places toilet to be provided as a requirement.
Training and awareness, and communication	• Lack of signage and information to indicate accessible entrances, or if entry is possible into certain areas; time and energy can be wasted trying to locate the entrance. • More information regarding whether certain places can meet the needs of people – e.g. can wheelchair users gain access with ease, or will they require assistance? • Some places require you to use their wheelchairs, this raises many concerns as it is not always possible to transfer or use an alternative chair.	• Information about locations and the facilities – **"…lack of information can lead to disappointment in children when arriving there and are unable to do anything."**

There was a general comment from the focus group around the confusion among companies on what they need to do – for example, failing to meet the requirements of Part M when providing accessible toilets. It is not always clear to building owners and managers what their legal duties are and what standards they should be following. Therefore, more awareness needs to be raised as to what accessibility means and how to make sure that this is implemented properly during design and construction.

Key quotes from the discussion:

- On circulation and space for mobility aids – **"Space in shops and restaurants, we have small manual chair, and we struggle to get seated at a restaurant, about to change to a large power chair so it will get harder".**
- On toilets - **"Some places have put in Changing Places, that make them better but can't think of anywhere that has done that much more, it's about so much more than one element."**
- On planning ahead: **"I don't want to take my child out then discover we can't do anything, I don't want to cause disappointment."**
- On independent access: **"Can't go out without my children as I get stuck because kerbs are too steep and no one to help push me up."**
- **"It's hard to think of places, hard to find places that have the level of accessibility that we need".**

Good practice examples

The focus group was asked to provide any good examples of places that accommodated their needs; the following places were identified:

- Folly Farm, South Wales, **"…with a Changing Places toilet, not too big, wheelchair accessible carriage on their big wheel, well laid out, somewhere we can go for a day out and access the same entertainment people would normally expect on a day out."**
- Ikea (West Thurrock) **"…toilets have good space, didn't need to have someone with you, don't want my children to have to do things for me, I could manoeuvre about and get to where I needed."**
- Good experience with National Trust, new café that is accessible but no Changing Place, trying to roll out to some of their sites.
- Cambridge Botanic Garden – **"…no Changing Place but accessible viewing platforms, with shallow ramp so you can see across the gardens".**
- Galloway – Changing Place toilet in visitor centre, level access into visitor centre and level path through the forest so you can go through the park, **"can enjoy a visit rather than just stopping at a service station".**

General comments from the group included both the need for CP toilets and the separation of CP toilets and accessible toilets. Some additional work within CP toilet design was identified, including addition of privacy screens.

Maintenance of CP toilets was important to ensure hoists are returned to the charging position.

Signage and way-finding information were also identified as important to inform wheelchair users of where, and how, to access the CP toilet.

Attendees also raised that access into parks and woods with children can be difficult at present, as entrance gates do not allow access for wheelchair users.

10.1.6 Focus group: D/deaf and hard of hearing people

A focus group for people who were D/deaf or hard of hearing was held to understand better what the challenges and opportunities are relating to the built environment. Three participants took part in the focus group. The following barriers and helpful features in places and spaces were identified:

Table 44. Common barriers and helpful features in places and spaces for D/deaf and hard of hearing people.

Category	Barriers	Helpful features
Building design	• Soft furnishings, lots of echoes and background noises makes it difficult to hear people, low lighting makes it difficult to lip read. • Large open rooms with hard flooring/marble flooring are difficult to be in as sound has nowhere to go. • PA systems are normally unintelligible due to bad quality of sound and acoustics. In an emergency, participants reported fears of not hearing the announcement. – At railway stations, platform changes announcements missed, having to rely on crowd movement. • Approaching busy reception areas. – Speech to text is not promoted as an option but would be useful in various situations. – If there are screens or grills at a reception desk / counter, it makes it very difficult to lip read.	• A design solution for lift emergency call systems will be helpful - e.g. if people press the emergency button in a lift, but do not respond to a voice response, how can help still be provided? • Reduction of spaces where echoing occurs, both through building design and materials. • Use of colours for wayfinding / directions.
Equipment	• Devices that require audible communication, particularly when poor quality. – Entry phones to buildings are not useable if you cannot hear the person, requiring users to simply stand and wait for someone to come and assist. • Induction loops were preferred over infrared by one participant, who reported constant issues with infrared systems. – Sanitation, maintenance and supply issues within theatre where infrared is installed, for example a theatre providing 4 boxes with loops and 4 with ear buds: usable for only 8 people. – More understanding and guidance on the systems available and the pros and cons for users • Feeling singled out in theatres: hearing assistance equipment is not subtle and draws attention to the user. • Pitch of audible alarms can cause physical pain. • Using emergency equipment that relies on verbal information / cues (e.g. defibrillators that provide verbal instructions). Participants felt that these should be able to be used by all.	• Some hotels give a vibrating pillow device. – **"Vibrating pillows should be standard and provided to everyone."** If these pillows are not provided, staff will simply need to remember there is a hard of hearing person staying at the hotel. • Some people do not wear hearing aids, so an induction loop is not always the solution.
Training and awareness, and communication	• Lack of guidance. – Guidance tells people to 'make allowance of hearing impaired' but no instructions of what to do. • More detailed information on accessibility systems within buildings and the processes in place. – For example, management plan during emergency situations, location of safe havens, buddy systems etc.	• Emergency pull cords in hotels – where provided, there is no information for the hotel as to what they should do when used – more guidance for operators would be helpful. • Training and guidance on the installation and use of loops.

Overall, comments from the group noted that there is lots of advice on physical access, but for D/deaf and hard of hearing people guidance just **"tells you to make allowances",** with no instructions of what to do. The general feeling was that hearing people do not understand what it is like to be D/deaf and hard of hearing, and solutions need to be formed and guidance on these solutions implemented.

The focus groups expressed feelings of exclusion and not having the **"right tools"** to be able to access buildings and spaces with ease. "**Part M and Standards are very dry and don't do enough**" – there was a strong feeling that Part M is standardised and not specific enough with regards to different disability types.

Key quotes from the discussion:

- **"I have almost forgotten what it is like to go to a public space."**
- **"It would be lovely if these things were standard, and we didn't always have to forward plan and make a fuss before visiting a building."**

- **“Difficulties when disabled people’s access needs clash: so need to make sure that what makes something accessible for one does not cause difficulties for other people.”**
- **“I am also physically disabled and if there is an emergency, no good shouting on a PA** (public address system), **you need a safe space to get out the way, need a buddy to get people out of the building without relying on verbal instructions.”**
- **“There’s nowhere that really jumps out as being amazing, most buildings I struggle with something, it isn’t possible to accommodate everyone.”**

Good practice examples

The following places were identified:

- A London theatre (unspecified) – helped with sound, mobility, getting in and out of the building, and there was a buddy. **“They have thought of everything, and it was a really good experience.”**
- A hotel (unspecified) - **“A hotel that automatically provided a pillow alarm, I could sleep soundly not relying on someone to wake me.”**
- **“Crematoria and churches tend to have the best loops that work well.”**
- **“Churches really are very good they have high beams and spaces, but it really works.”**
  - One participant explained their local church was not particularly accessible and they needed to learn where to sit to make the hearing loop work.

10.1.7 Focus group: Blind and partially sighted people

The focus group was asked about the most common barriers experienced in places and spaces. Four participants took part in the focus group. There was general consensus that challenges ranged from access into a building, circulation within spaces, wayfinding, need for audible information, lighting and they types of materials and surfaces used. The following barriers and helpful features in places and spaces were identified:

Table 45. Common barriers and helpful features in places and spaces for blind and partially sighted people.

Category	Barriers	Helpful features
Approach and entrance to a building	• Seating displays and 'A' (advertising) boards obstructing access. • Identifying doors when glazed and closed. • Lack of space close to entrance doors. • Finding staff assistance or a help desk.	• Slopes are always easier than steps.
Circulation	• Lack of clear width in aisles and around entrances. • Large mirrors or glazing making spaces difficult to navigate.	
Wayfinding and communication	• No braille or tactile information in lifts. • Hard to orientate yourself. • Lack of audible announcement. • Anywhere you must touch in or scan a code. • Lack of accessibility setting on touch screen. • No Wi-Fi to access information/apps. • People do need to be aware of the law around guide dogs. • Perspex screens.	• Internal beacons with GPS navigation systems that you download on your phone and periodically will let you know you have just past places. • Tactile buttons.
Internal features	• High counters. • Lighting too bright and reflective surfaces. • Lack of circulation space. • Reverberation and echo. • Soft barriers.	
Sanitary facilities	• Lack of accessible toilets. • Cannot identify and find features in accessible toilets. • Cleanliness. • Used as a storeroom. • Standard cubicles too small to take a guide dog in.	• Step free access to accessible toilets. • Audible systems in toilets to describe the layout of the space.
External environment	• No contrast between paving and external seating. • Pavement parking. • Overhanging bushes. • Nowhere to cross. • Uneven pavements. • Metal tactile paving. • Shared surfaces.	• Tactile paving. • Consistent street furniture. • Barriers in the street environment.

Overall comments noted from the group that changes in the layouts in different environment such as positions of tables and chairs, reflective surface and mirrors, lack of space to circulate in premises and finding staff or physical features all provide significant barriers. In addition the concentration required to navigate the environment is not taken into consideration - "**The concentration level with a cane is so much higher, the cane is like a saloon car it does the job but a dog is like a Ferrari it is quicker and better"** nor space to accommodate a guide dog **- "Not enough accessible toilets in areas, so have to sometimes try and use smaller cubicles and you can't always get in with your dog, then you have to sit with the door open".**

Key quotes from the discussion:

- On shared spaces: ***"*Shared spaces please don't bring them back, they are dangerous, people think about wheelchair users but to not have an indicator to tell the difference between a cycle way, pavement and road, dogs are trained to stop at kerbs if they aren't there it is very difficult".**
- On audible announcements: **"These devices can be installed at what I feel us a very reasonable price and can easily be re-programmed if the layout of the room changes, so it's adaptable. If it was me, I'd like to see these devices used more widely, not just for accessible toilets but for all buildings which have public access, if these devices were used, particularly in buildings such as Council offices I bet I would be able to access these areas and their services fully independently".**
- On identifying features: **"Using the same-coloured material for the stone shaped seats as the floor, they blend in and are a knee height so you walk into them as you can't see them. Sometimes you bump into people because you can't see them on the sitting on the seat."**
- On navigation: **"Using a cane is more difficult particularly in public spaces where there is pavement clutter, pavement parking, A-boards** (advertising boards), **seating, you have to knock into them. You have to whack things with your cane, people get cross with you hitting things."**
- On lighting – **"Lighting is often overpowering I have small amount of sight but if it is too bright it takes my sight away".**

Good practice examples

The following places were identified:

- **"Basingstoke town centre is laid out in a grid system so almost all straight lines so helpful for me to map it out in my head. Most of it is straight lines so easy to navigate."**
- **"In Holland, they have tactile wayfinding routes from bus station to the main parts of the town and city centres so if a cane user really useful."**
- **"Italy have them and used them around Rome and it was a really liberating experience every so often Braille information provided."**
- In Cornwall, **"…walked into toilet and audio description of the layout of the toilet was given to me after waving my hand in front of the door. Should be standard in all accessible toilets."**

10.2 Summary and key findings

The focus groups aimed to gain in-depth insight into the views and experiences of specific groups of disabled people and people with long-term health conditions about the built environment in England.

Each focus group provided lived experience comments about both the barriers and helpful features they have experienced in places and spaces. Participants also shared personal examples of places that accommodated their needs.

Focus groups attendees had a wide range of views, requirements and examples to share. Within each group there was largely agreement about what the main issues are and what was causing barriers, although barriers and solutions varied significantly between groups.

Some themes emerged consistently across all or most groups, including (direct quotes are provided in **bold**):

Lack of awareness, interest and care given to accessibility

Attendees expressed frustration at a lack of thought given to accessibility in design of the built environment. The cost of making spaces accessible, and the difficulty of accommodating multiple different needs, was brought up repeatedly as a reason why a lack of access exists.

Both the wheelchair user and Changing Places focus groups were particularly focused on non-compliance, and an opinion that there was limited pressure and enforcement on designers or building owners to comply with the regulations and standards that exist. In the other focus groups, the more pertinent concern was a lack of provision in standards for particular access needs beyond mobility.

“It is the little things. If you go into a toilet and see some thought has gone into it, your whole experience changes. You pass on that experience to others, retailers see the difference too as you keep going back to it.”

A need for user testing in design

Attendees noted that good design should be user-tested by disabled people to ensure that accessibility is addressed well. Attendees noted that it was clear when buildings had conducted user-testing and consultation as a better level of access would be achieved.

Information

Attendees raised that having good accessibility information about places - available in advance - was vital. This could mean information provided online by service providers, for instance, detailing the parking, layout and facilities. Some attendees reported spending hours trying to find out accessibility provisions in advance of travelling, while others reported having to leave places or take different routes as access information was unavailable or inaccurate.

Joined-up thinking

Attendees relayed frustration with a lack of ‘joined up thinking’ across design – referring to individual access barriers that result in a whole space becoming inaccessible. For example, accessible facilities (such as an automated door) that are not maintained and so do not work, or an accessible toilet with a step along the route to the toilet.

Difficulty identifying good examples

Attendees typically responded that there were very few or no places that accommodated all needs well.

11. Objective 2b: Quantitative research

Quantitative experimental data was collected on wheeled mobility aids, including the dimensions of static wheeled mobility aids and the manoeuvring space dimensions for users of wheeled mobility aids.

The study focused on two key Research Streams:

- The percentile dimensions of static wheeled mobility aids, and comparison with both the equivalent percentile dimensions recorded in previous research studies and the current design guidance in England relating to space requirements for wheeled mobility aids (see Section 12).
- The percentile manoeuvring space dimensions of wheeled mobility aids completing both a 90º and 180º turn (see Section 13).

The study was important to establish the current dimensions of 'in-use' wheeled mobility aids in England and, subsequently, the appropriateness of the current spatial standards for the built environment.

Experimental data was collected by Loughborough University (LU) via:

- A photogrammetric survey of occupied wheeled mobility aids, building on previous equivalent surveys (e.g. 'A survey of Occupied Wheelchairs and Scooters' (weight of mobility aid and occupant), Department for Transport, 2005).
- Additional studies of reach and manoeuvring space requirements for wheeled mobility aid users.

Key percentiles

Population profiles, including the UK population, are normally distributed. The most reported percentile range for anthropometric measurements is the 5th-95th percentile[39]. In height, for example, the 5th-95th percentile would exclude the shortest 5% and tallest 5% of people measured to provide an indicative range without outliers.

To provide a range of options for consideration, we have included the following percentile for each data point 85th, 90th, 95th, and 99th. It is not necessarily the recommendation of this report that such percentiles are used in design.

Human factors specialists recommend that 5th percentile female and 95th percentile male anthropometric data points are used in design[xlix] to ensure that at least 95% of the target population is catered for.

For best practice, it is recommended to provide design guidance that would accommodate all users (0.001-99.999% of people measured), as this accommodates edge cases who may have significantly different body size or shape to the mean. This would also provide

[39] Aggregate summaries of PeopleSize 2020 data used in ergonomics typically work to the 95th percentile, meaning measurements exclude those that are 2.5x the standard deviation, and that accommodate, as a minimum, 95% of the target population for operations and maintenance. This is achieved by designing for a range of body dimensions from 5th percentile female to 95th percentile male.

greater flexibility and contingency against future anthropometric changes. The use of the 99.9th percentile would be considered the most inclusive.

12. Research Stream 8: Photogrammetric survey

The photogrammetric survey aimed to collect experimental data on the dimensions of static wheeled mobility aids in England and to compare this with both the equivalent percentile dimensions recorded in previous research studies and the current design guidance in England relating to space requirements for wheeled mobility aids.

To achieve this, experimental data on wheeled mobility aids was collected by a research team from LU with support from the Occupational Therapy Service (TOTS).

LU has strict data protection rules for research activity and all data collected for the study was subject to LU's internal ethical review process / approvals process and associated communication protocols to the participants.

A photogrammetric method was used based on the methodology used for previous research in this field including:

- Stait R E, and Savill T A. 1995. A survey of occupied wheelchairs to determine their overall dimensions and characteristics. TRL Report 150[I].
- Stait, R.E., Stone, J. and Savill, T.A., 2000, A survey of occupied wheelchairs to determine their overall dimensions and weight: 1999 Survey. TRL Report 470[Ii].
- Hitchcock, D. et al, 2006, A Survey of Occupied Wheelchairs and Scooters conducted in 2005. Department for Transport report.

Data and measurements were collected about wheeled mobility aid users. A variety of measurements were taken, including the length, width, and height of occupied wheeled mobility aids with and without an attendant pushing the wheeled mobility aid (where applicable).

The anthropometry measures and functional space observations was completed by the trained research team at LU and TOTS collaboratively. Training was given by the LU research lead to the research assistants engaged on the project, to ensure standardisation of the measurement methods, and a standard demographics questionnaire was used to collect basic information about participants.

Figure 37 summarises the data collected from participants as part of the study, the purpose for collecting the data and the method used in the study.

The participant information sheet used to collect the key demographic data is contained in Section C.1 in Appendix C.

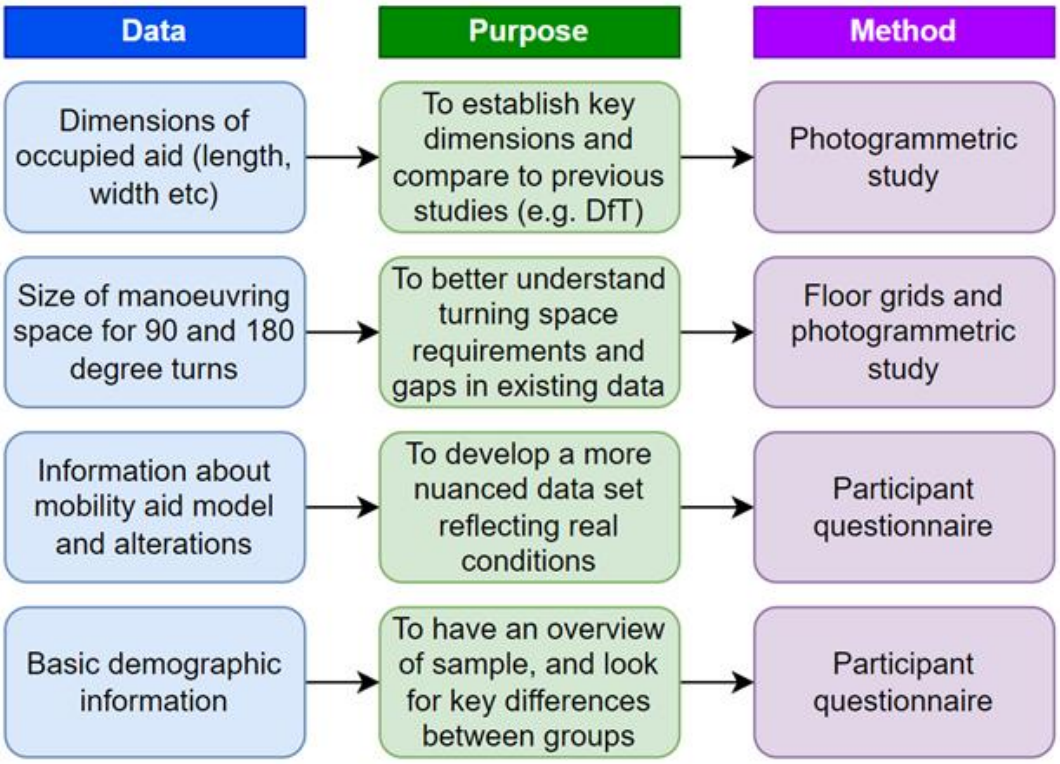


Figure 37. Data and method of collection for the wheeled mobility aids study.

The method for data collection was based on the methods described in the 2005 DfT report to enable consistency and comparison between the data sets. This involved two cameras, with photos taken at head height and thigh height from five positions around the occupied wheeled mobility aid. A measured and graded rig was constructed to allow accurate measures to be taken from the images.

To collect participant data, participants undertook the following process:

1. The participant seated within their wheeled mobility aid was aligned with the measurement grid to maximise parallax and improve accuracy from the photo-grammatic measures.
2. Anterior pictures (i.e. pictures taken of the front of the participant) were taken from a central position.
3. Lateral pictures (i.e. pictures taken of the side of the participant) were taken from shin / footplate, central / mid-thigh, and rear handle position.
4. Posterior pictures (i.e. pictures taken of the rear of the participant) were taken from a central position.
5. The participant seated within their wheeled mobility aid moved to the weigh scale to take overall mass.
6. The trial is complete.

All images were individually numbered, and no personal identifiers are linked with any of the images.

For each participant, anthropometry measures from the photogrammetric study reported:

1. Height of the occupant using their wheeled mobility aid.

2. Length of the occupant using their wheeled mobility aid.
3. Width of the occupant using their wheeled mobility aid.
4. Combined weight of occupant and their wheeled mobility aid (see Figure 38).
5. Wheelbase of the wheeled mobility aid.
6. Height of the armrest or height of the wheeled mobility aid controls.
7. Distance between the wheeled mobility aid handles (see Figure 38).
8. Angles at the front wheels of the mobility aid.
9. Angles at the rear wheels of the mobility aid.
10. Width of the user at their widest point when using their wheeled mobility aid.

Figure 38. LU research team demonstrating measurement of combined weight of occupant and their mobility aid (left image) and distance between the wheeled mobility aid handles (right image).

For each participant in the study, photograph sets were taken in the following positions:

- Stationary, with user resting hands in a comfortable position in lap
- Preparing to move, with user placing hands on the device wheels or controls

This allows an overview of specific data points – for example, evaluating both the width of the wheeled mobility aid itself and the width of the wheeled mobility aid when occupied and in use.

12.1 Sample

The analysis in this section is based on a sample of 711 occupied wheeled mobility aids, collected between September 2021 and September 2022. An Interim report was issued to DLUHC in March 2022 (461 sample size).

Data was collected at a range of locations across England including Naidex roadshow, sporting events, outdoor events and indoor classes:

Table 46. Data collection locations.

Location	Sample size
Birmingham	295
Loughborough	127
Oxford	76
Stoke	51
Coventry	46
Liverpool	44
Manchester	31
Leicester	15
Nottingham	10
Sheffield	8
London	6
Norwich	2

No significant differences in size were noted across the different data collection sites.

The sample size was less than achieved in the 2005 DfT study[40]; however, this was due in large part to the COVID-19 pandemic and its impact on people's behaviour, particularly people with complex and multiple disabilities.

The research study was scoped when the full impact and length of the COVID-19 pandemic was unknown and this had a more significant impact on the research study than could be foreseen. Due to national restrictions on mobility and social contact during this time, many events identified for data collection were cancelled or held online. People's travel behaviour was also significantly impacted once these restrictions were removed, with people less willing or nervous to travel to events where data collection took place.

Several practical issues also impacted on the sample size achieved, including difficulty acquiring venues to collect data and reluctance from organisations and institutions - particularly educational and health care settings - to allow access. Delays were also caused by the project and research teams catching COVID-19, school holidays (impacting availability of educational venues), an additional scope of work completed by Arup and LU for the DLUHC during this research project, and bank holidays, including the mourning period following Queen Elizabeth II's death, that also, impacted on research team availability.

While it was not possible to achieve a sample size similar to the 2005 DfT study, the sample size was similar to the sample size of the 1999 DfT study. It also included a distribution of wheeled mobility aid types in keeping with the previous DfT studies (see Section 12) and collected data from a range of different sites and events in England.

It should also be noted that the 90th percentile 'footprint' (see Section 12.3.1.5) and manoeuvring space dimensions (see Section 13.2.2 and Section 13.3.1) recorded in this

[40] For the 2005 DfT study, data was collected from 1356 participants: 1098 adults and 247 children.

study (711 sample size) are similar to those obtained at the interim stage of the study (March 2022, 461 sample size) suggesting a robustness to the findings.

12.2 Demographic data

12.2.1 Age

488 participants provided details about their age (not all participants provided demographic information).

The highest proportion of people were in the 26-35 years age bracket and the lowest proportion of people in the 65+ years age bracket (see Figure 39).

Of participants in the 0-18 years age group, 31% were aged 10 or under. Of participants in the 65+ years age group, 18% were over 75 years old. This potentially represents a data gap for children and older adults.

It should be noted that the data gap for children is mitigated by the fact that some children use rehabilitation buggies, rather than wheelchairs (these are buggies/mobility aids that offer additional support for children); 8 rehabilitation buggies were included in the wheeled mobility aid scope and sample.

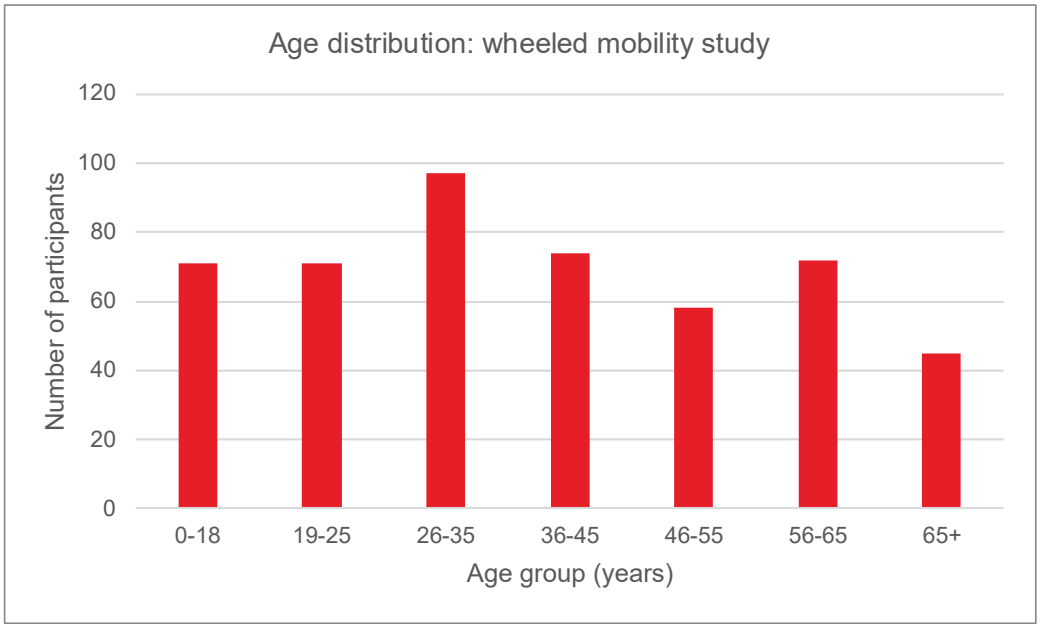


Figure 39. Age distribution in the wheeled mobility aid study.

The age distribution findings could result from:

- Data collection sites: for ethical reasons and restrictions due to COVID-19, it was not possible to collect data in schools, where the bulk of under-18 data could have come from.
- Distribution of disability and mobility aid use: although limited robust data exists on the age distribution of wheelchair use, it may be that older people (e.g. 55-65) are more likely than younger people (e.g. 18-25) to use wheelchairs, as the prevalence of disability on average increases with age.
- COVID-19: older adults are known to be at greater risk from COVID-19[lii] and may as a result have been less willing to travel to data collection sites.

12.2.2 Gender

503 participants reported their gender (not all participants provided demographic information). Of these, 285 were male, 217 were female and 1 participant identified in another way.

12.2.3 Ethnicity

500 participants reported their ethnic group (with a third of participants choosing not to provide ethnicity demographic information). Of these, 93% were white, 2% were Black / Caribbean, 3% were Asian / Asian British and 2% reported another ethnicity.

This represents a data gap for ethnic groups other than White. Targeted sampling to address this gap has not been feasible in this research, as it is not generally possible to collect data about participants in advance of data collection.

However, this data gap is not considered likely to cause a significant alteration in the size of a wheeled mobility aid, nor the manoeuvring space requirements for a wheeled mobility aid, as any size difference is largely dictated by the size of the wheeled mobility aid rather than the physical features / size of the user.

12.3 Wheeled mobility aids

The wheeled mobility aid type and model used by participants was recorded. Three principal mobility aid types were identified:

- Powered
- Self-propelled
- Attendant-propelled

These types are not mutually exclusive. For example, a wheeled mobility aid could be self-propelled with the additional of a hybrid motor, or a powered mobility aid could also be pushed by an attendant.

46 wheeled mobility aids measured fell into more than one category.

40 participants also used ambulant mobility aids such as crutches or walking frames in addition to their wheeled mobility aid. In a few cases, participants used ambulant mobility aids and wheeled mobility aids simultaneously – e.g. crutches used to help propel a manual wheelchair.

20 participants with mobility scooters were included in the sample (note mobility scooters are included in the full data set but not included in any other mobility aid category).

8 rehabilitation buggies were also included in the sample.

Table 47 sets out the achieved sample size for each mobility aid type. Note, some types belonged to more than one category, so the numbers in the table total more than the total number of participants.

Table 47. Total number of wheeled mobility aid types used by participants.

Wheeled mobility aid type	Sample size (total / percentage)[41]
Powered mobility aid	313 (44%)
Self-propelled mobility aid	297 (42%)
Attendant-propelled mobility aid	117 (17%)
Mobility scooters	20 (3%)

It is not possible to assess if this sample is representative of the prevalence used by the population as there is no generalisable or centralised data sources for the actual prevalence of different mobility aids in England. However, the sample and sampling approach that was adopted is consistent with previous studies (i.e. allowing for comparison). These previous studies were designed to be reproducible in approach, and the repeated conducting of the same study (i.e. studies in 1995, 1999, 2005) allows trends over time to be established.

As with the 2005 DfT study, this research includes a summary of the key data points and percentiles as below:

- Overall percentiles for the whole sample
- Percentiles for each category of wheeled mobility aid

The sample in this research has not been weighted to match the distribution in these previous studies; this is because all these studies note that the sample has changed over time and none of the previous studies have been weighted. Therefore, there is no reason to assume that it would be more accurate to weight our findings according to an unweighted convenience sample (i.e. from the 2005 DfT study).

Furthermore, it is not possible to establish with certainty if the changes in prevalence are because the actual proportion of powered mobility aids is increasing, or because the proportion of people using powered mobility aids to attend events where the samples were taken (i.e. Naidex roadshow) is increasing.

The distribution of mobility aids in this study is not identical to the 2005 DfT study: this study includes around 17% more powered mobility aids and 4% more attendant-propelled mobility aids. However, both increases are relatively consistent with the changes in distribution between the 1995, 1999 and 2005 studies.

12.3.1 Static dimensions: all wheeled mobility aids

12.3.1.1 Length

To understand the possible space requirements of different wheeled mobility aid types, length has been provided for occupied wheeled mobility aids both with an attendant (where applicable) (i.e. wheeled mobility aid, user and attendant combined) and without an attendant (wheeled mobility aid and user combined) (see Figure 40 and Table 48).

[41] Note, sum of sample size total / percentage is greater than 711 / 100%, as some wheeled mobility aids belonged to more than one type of category.

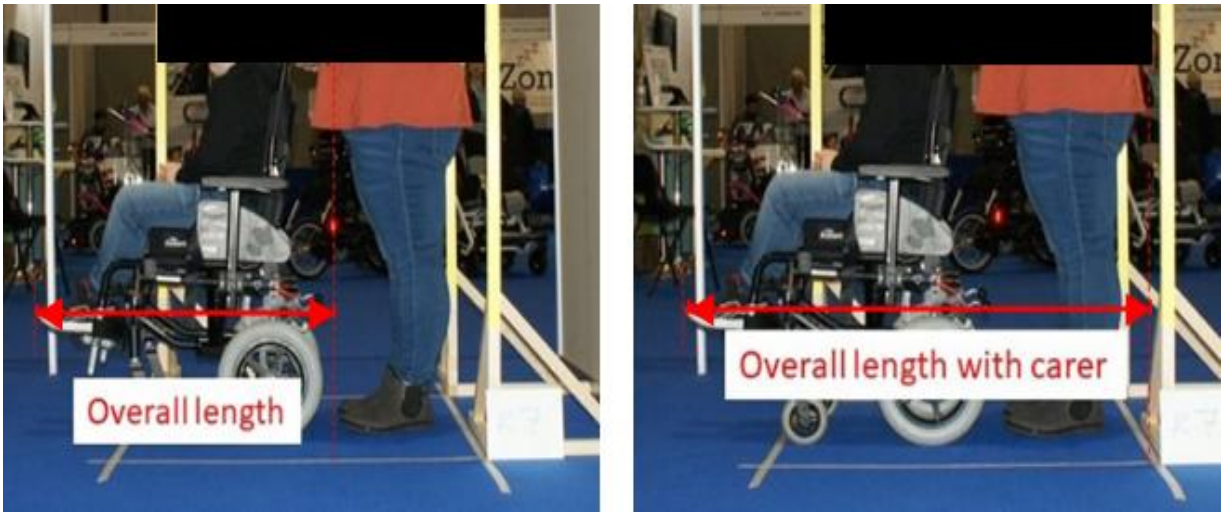


Figure 40. Example length measurements.

Table 48. Key percentiles: length of occupied wheeled mobility aids.

Percentile	85th	90th	95th	99th
Overall length of occupied wheeled mobility aid (m)	1.42	1.49	1.59	1.76
Overall length of occupied wheeled mobility aid with attendant (m)	1.88	1.97	2.04	2.14

The median length for an attendant-propelled mobility aid was greater than for a wheeled mobility aid without an attendant. However, without including the attendant as part of the length, both the longest self-operated and powered wheeled mobility aids were generally longer than attendant-propelled mobility aids[42].

The longest wheeled mobility aids were powered mobility aids in a reclined position (i.e. where the user is not fully upright). This was the case for wheeled mobility aids both with and without attendant.

12.3.1.2 Width

To understand the possible space requirements of different wheeled mobility aid types, both the width of the mobility aid and the widest point of the user with their hands in the typical position for movement (e.g., for a manual wheelchair, with hands resting on the wheel rims; for a powered mobility aid, with hands on the controls) was measured (see Figure 41 and Table 49).

[42] However, note, the sample size for attendant-propelled mobility aids was smaller than the sample for self-propelled and powered mobility aids.

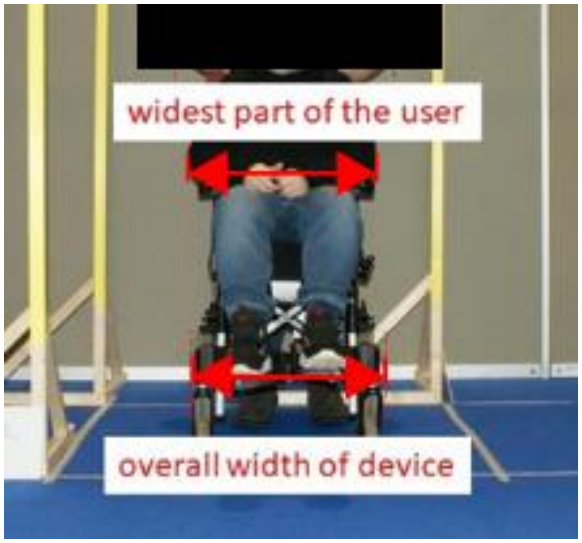


Figure 41. Example width measurements.

Table 49. Key percentiles: width of occupied wheeled mobility aids.

Percentile	85th	90th	95th	99th
Overall width of wheeled mobility aid (m)	0.77	0.80	0.85	0.98
Widest part of user (arms) (m)	0.84	0.87	0.93	1.09

The widest part of the user using their wheeled mobility aid was in general wider than the width of an unoccupied wheeled mobility aid.

This disparity reflects the findings in Annex G of BS 8300-2, which identified a 90th percentile width of 720 mm (for an 'occupied' wheeled mobility aid) and 697 mm (for an 'unoccupied' wheeled mobility aid). However, the widths identified in this research study are greater (870 mm and 800 mm respectively) for the same measures.

It should be noted that not all wheeled mobility aids are wider when in use – the design of some wheeled mobility aids means users keep their arms within the width of the mobility aid when moving.

12.3.1.3 Height

Overall height is measured from the floor to the top of the occupant's or attendant's head, or to the top of the wheeled mobility aid (if higher) (see Figure 42).

The armrest height refers to the height from the floor to the top of the wheeled mobility aid armrest (or lap/seat height if the aid has no armrest). For some wheeled mobility aids, armrests are adjustable – in all cases the armrest height was taken at the occupant's preferred / typical height at the date of the measurement.

Table 50 provides the key percentiles from this study.

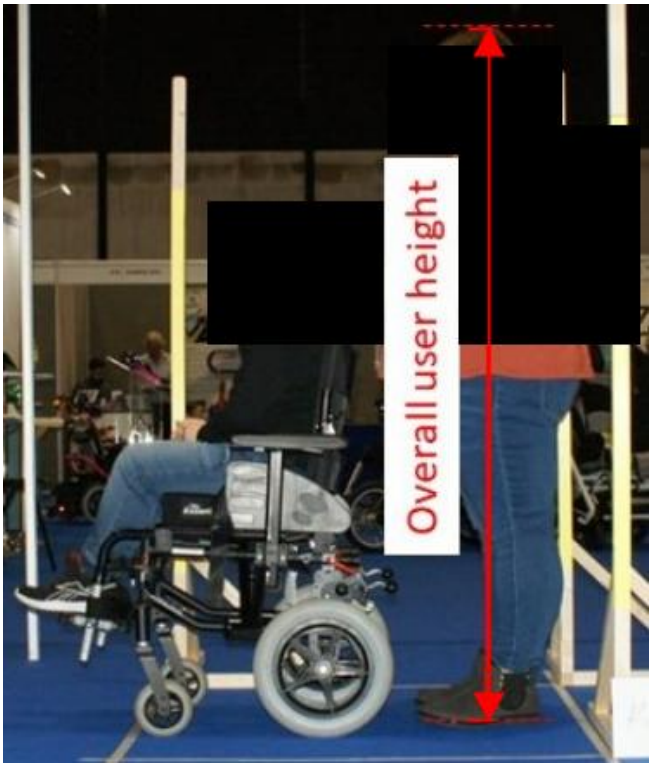


Figure 42. Example height measurement.

Table 50. Key percentiles: height of occupied wheeled mobility aids.

Percentile	85th	90th	95th	99th
Overall height of wheeled mobility aid and user (m)	1.56	1.63	1.70	1.82
Armrest height (m)	0.85	0.89	0.94	1.15

A range of different heights was recorded, up to 1.87m for the tallest occupied wheeled mobility aid (i.e. aids with a seat raiser, allowing the user to stand vertically while moving).

12.3.1.4 Length and width

Figure 43 and Figure 44 indicate the 85th, 90th, 95th and 99th percentile dimensions for the length and width of occupied wheeled mobility aids across a range of categories:

- All mobility aids
- Powered mobility aids
- Self-propelled mobility aids
- Attendant-propelled mobility aids
- Mobility scooters

The 50th percentile (median) dimension has also been indicated for the sake of comparison.

Wheeled mobility aids falling into multiple categories / hybrid aids have been counted in all relevant categories.

For all wheeled mobility aid types, when measured without an attendant, self-propelled mobility aids had the lowest median length, while powered mobility aids had the highest median length without an attendant.

For all wheeled mobility aid types, when measured with an attendant, self-propelled mobility aids (in this case, comprising the length of aids which could be either self- or attendant-propelled, when an attendant was propelling them) were again the shortest, followed by powered mobility aids, with attendant-propelled mobility aids being the longest.

What this data indicates is that wheeled mobility aids which are only attendant-propelled (i.e. those which do not have the option / capability for independent operation by the occupant), are typically longer than those with dual operation, such as a self-propelled mobility aids with handles for assisted use where required. This could be because people who use wheeled mobility aids that are attendant-operated and who are not able to operate powered mobility aid controls are likely to have more complex requirements which often results in a larger wheeled mobility aid. For example, attendant-propelled mobility aids with users in a reclined position, rather than seated upright, would fall into this category.

Mobility scooters were excluded from the attendant-propelled measure as no mobility scooters that could be attendant-propelled (if these exist) were included in the sample.

The findings also show a difference between the width of an unoccupied wheeled mobility aid and the width of an occupied wheeled mobility aid (with the user's hands in the position they would typically be in to move). Although self-propelled mobility aids are on average slightly narrower than powered mobility aids, they are wider when the arms of the user are taken into consideration. This is because powered mobility aids, even when operated independently, are less likely to require the user to place their arms outside the mobility aid when moving as controls will generally instead be near or within the bounds of the mobility aid.

Mobility scooters are the narrowest devices on average, likely due to the reduced wheelbase.

See Section 13.3 for more information on the spatial dimensions for independent-use wheeled mobility aids only (i.e. aids without an attendant).

See Section C.2 in Appendix C for a tabular summary of percentile data for occupied wheeled mobility aids.

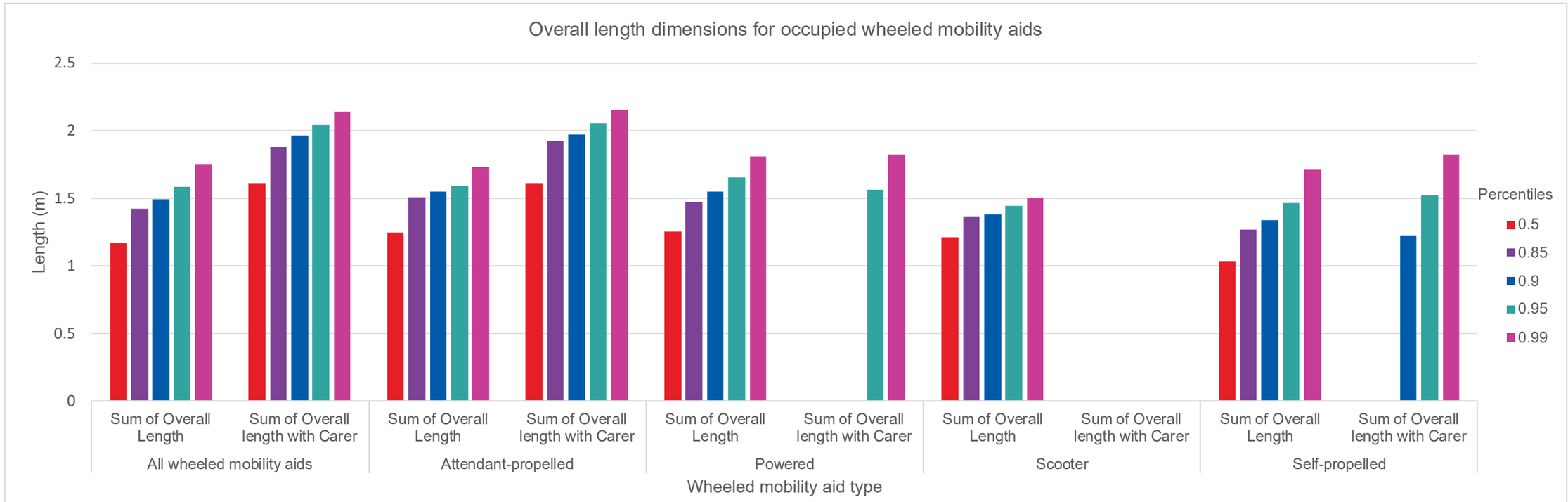


Figure 43. Key percentile length dimensions for occupied wheeled mobility aids – by type of wheeled mobility aid.

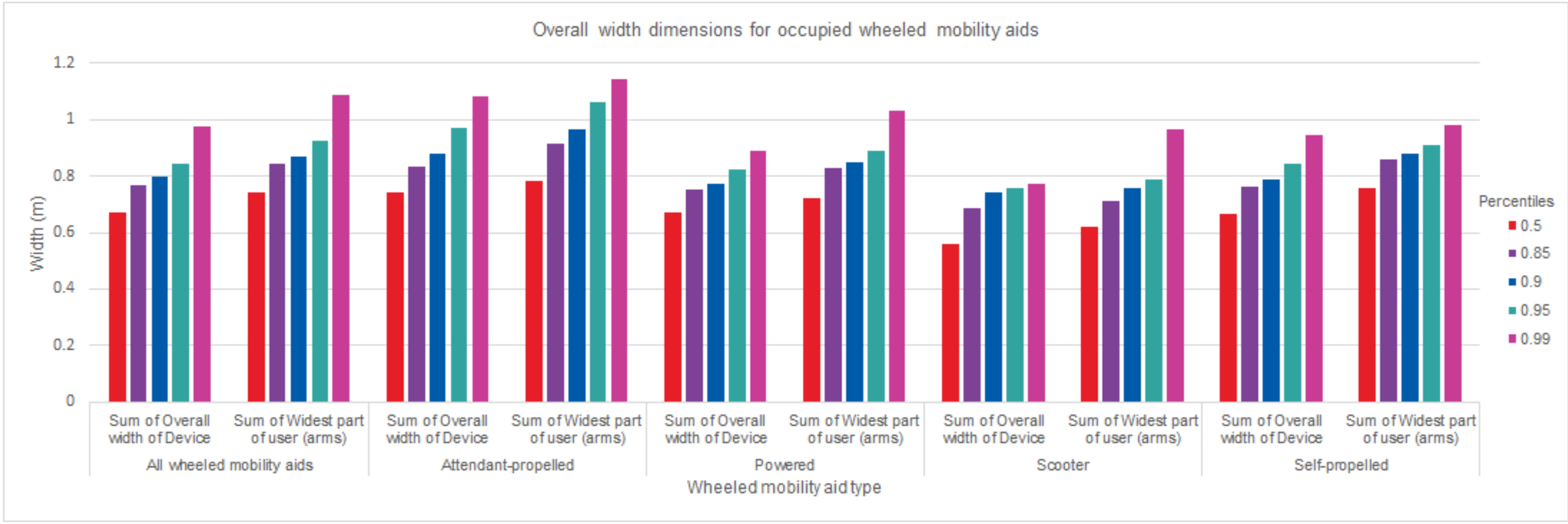


Figure 44. Key percentile width dimensions for occupied wheeled mobility aids – by type of wheeled mobility aid.

12.3.1.5 Footprint

The 'footprint' of a mobility aid refers to the space required to accommodate a stationary, occupied mobility aid.

The footprint of a wheeled mobility aid is relevant to a range of different pieces of guidance in Approved Document M (ADM) Volume 2, including space required for a wheelchair space in seating, and the minimum dimensions for a platform lift.

In current guidance, the footprint space required for a wheeled mobility aid is typically noted as 900mm x 1400mm (e.g. see Clause 3.34g of ADM).

The footprint resulting from the experimental data collected in this study has been plotted below for all occupied wheeled mobility aid types. Two footprints are provided:

- Plotting the length against the width of the wheeled mobility aid (see Figure 45).
- Plotting the length against the width of the widest part of the user (see Figure 46).

The 90th percentile footprint measurement (as used for current ADM Volume 2 guidance) has been indicated for each dimension with solid red lines on both Figure 45 and Figure 46. Dimensions have been rounded to the nearest 5mm.

Table 51 sets out the 90th percentile footprint measurements from the study against current footprint guidance. Other percentile measurements are contained in Section C.2 in Appendix C.

Table 51. Current footprint guidance against 90th percentile dimensions for wheeled mobility aids.

Current footprint guidance (length x width)	Source	Length x width (wheeled mobility aid only) (90th percentile)	Length x width (widest part of the user) (90th percentile)
1400mm x 900mm	ADM 3.43g, 4.12g	1495mm x 800mm	1495mm x 870mm

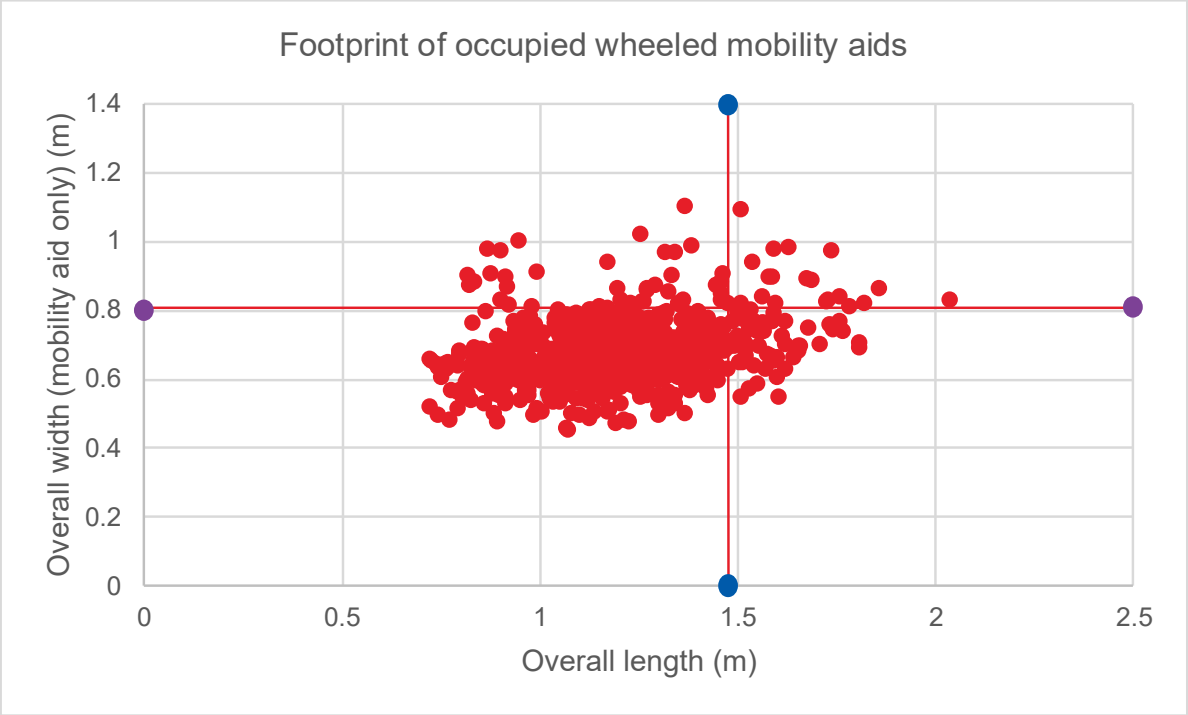


Figure 45. Length and width (mobility aid only) of occupied wheeled mobility aids (without attendant).

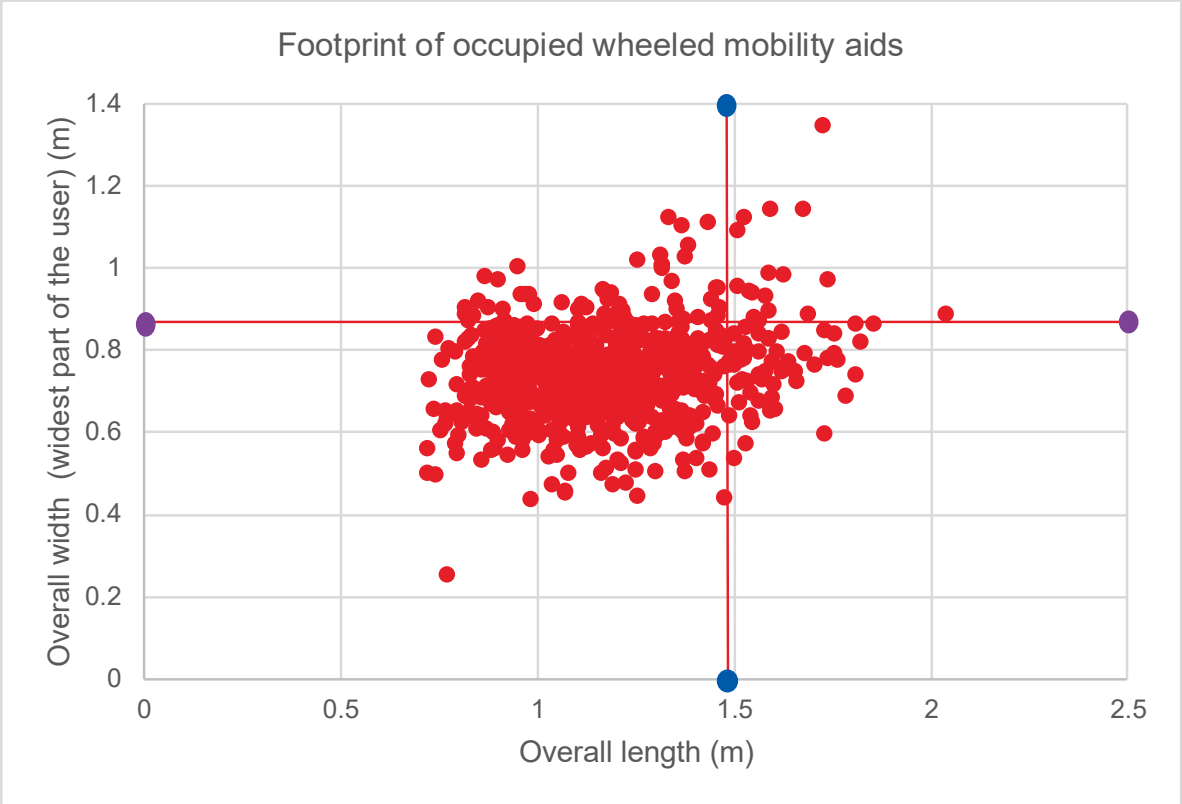


Figure 46. Length and width (widest part of the user) of occupied wheeled mobility aids (without attendant).

12.3.2 Weight

Weight was measured both as the device weight and the weight of the device and user, including any bags or equipment they had attached to their chair. It should be noted that weight was not taken for the full sample as:

- The weight equipment was not available at the first data collection site.
- Not all participants consented for their weight to be tested.

Some measurements were taken for comparative purposes using unoccupied exhibited chairs at mobility events) and did not include users in the weight measurement.

Table 52. Key percentiles: weight of occupied mobility aids.

Percentile	50th	85th	90th	95th	99th
Weight of device (unoccupied) (kg)	45.2	170	177	190	196.4
Weight of device and occupant (kg)[43]	114.6	233.88	249	268.8	298.8

Figure 47 indicates the 85th, 90th, 95th and 99th percentile dimensions for the weight of occupied wheeled mobility aids. The 50th percentile (median) dimension has also been indicated for the sake of comparison.

Self-propelled mobile aids were significantly lighter than powered mobility aids on average, with a median weight of just 14.5kg. Attendant-propelled mobility aids likewise had a lighter median weight. This can be expected as powered mobility aids include the weight of a motor and frame to support the motor.

However, both self-propelled and attendant-propelled mobility aid types had some outliers that were significantly heavier than powered mobility aids – these would be hybrid or powered mobility aids that also had a self- or attendant-propelled option, which would fall into multiple categories.

No measures for unoccupied scooter weights were taken as no participants were able / willing to exit from their scooter.

Occupied powered mobility aids had the greatest weight, up to 350 kg at the upper end of the scale.

[43] Note that this measure includes the weight of the person in the chair but excludes the weight of any attendant / person pushing chair.

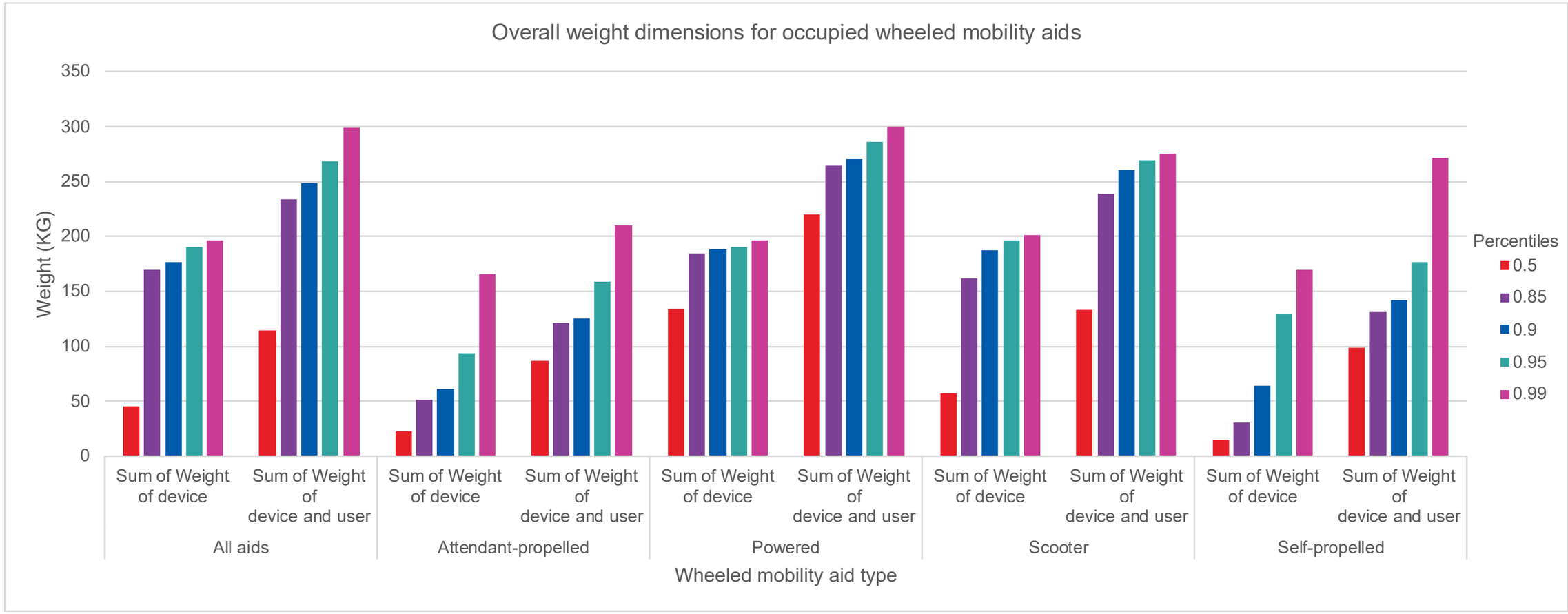


Figure 47. Key percentile weight dimensions for occupied wheeled mobility aids – by type of wheeled mobility aid.

12.4 Summary and key findings

The study aimed to collect experimental data on the dimensions of static wheeled mobility aids in England and to compare this with both the equivalent percentile dimensions recorded in previous research studies and the current design guidance in England relating to space requirements for wheeled mobility aids.

The key findings are:

- Different types of wheeled mobility aid have different spatial dimensions. This is primarily due to needs of their users and the way the mobility aid is therefore designed and used. For instance, although self-propelled mobility aids are on average slightly narrower than powered mobility aids, they are wider when the arms of the user are taken into consideration. This is because powered mobility aids, even when operated independently, are less likely to require the user to place their arms outside the mobility aid when moving as controls are typically within the bounds of the mobility aid.
- The 90th percentile length of an occupied wheeled mobility aid is 1.49m (increasing to 1.96m with an attendant).
- The 90th percentile width of a wheeled mobility aid is 0.80m, increasing to 0.87m when occupied and the widest part of the user is included.
- The current ‘footprint’ dimensions to accommodate a stationary, occupied wheeled mobility aid in ADM Volume 2 (e.g. for wheelchair space seating and platform lifts etc.) are 1400mm x 900mm (length x width; minimum). However, the findings from this study indicate this would be too small to accommodate most wheeled mobility aid users. The 90th percentile findings indicate a slightly smaller width, but a larger length of 1490mm.
- The study findings indicate that the current ‘footprint’ guidance will accommodate the 80th percentile of all wheeled mobility aid types in this study.

13. Research Stream 9: Manoeuvring space

The photogrammetric survey aimed to collect experimental data on the percentile manoeuvring space dimensions of wheeled mobility aids completing both a 90º and 180º turn.

To achieve this experimental data on wheeled mobility aids was collected by a research team from LU as outlined in Section 3.

Manoeuvring space measurements for participants to turn within their wheeled mobility aids was measured using floor grids (see Figure 48).

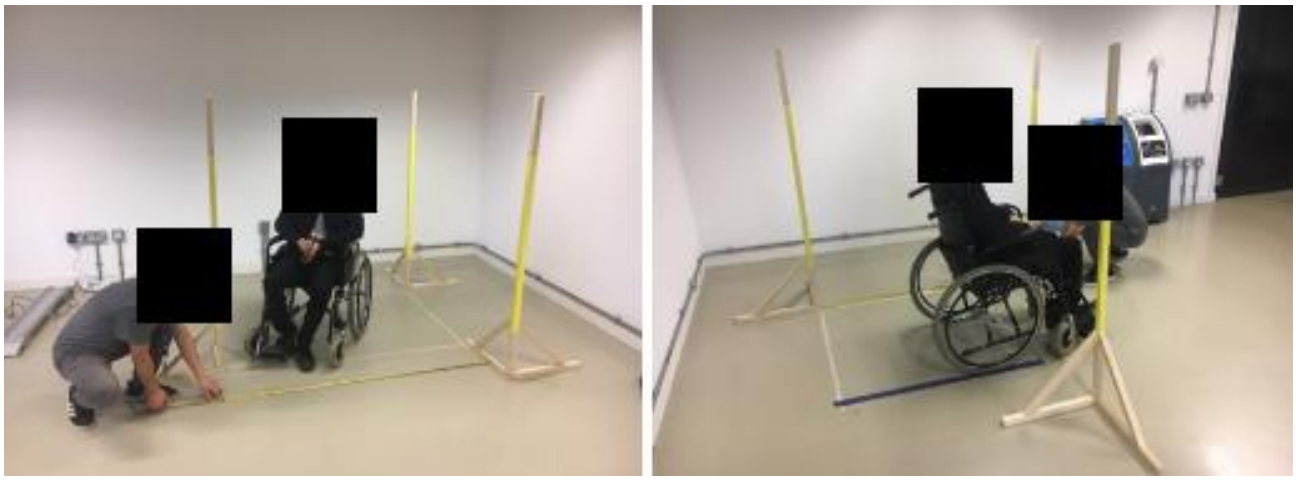


Figure 48. LU research team demonstrating measurement of anterior posterior length of the 90º turning square (left image) and breadth of the 90º turning square (right image).

Users were asked to turn in their preferred manner. Because of this, where the wheeled mobility aid was of a hybrid type, it is the space requirement of the users' preference that is recorded (for example, if a wheeled mobility aid could be both self- and attendant-propelled, it was the participant's preference whether the attendant was involved in the test).

While the 90º and 180º percentile measurements provided in this report represent the minimum dimensions of participants to turn, the study was conducted in an open space, with no obstruction present (e.g. walls, barriers etc.), and participants were not encouraged nor obliged to restrict the space taken to turn. The dimensions in Section 13.2.1, therefore, represent the preferred manoeuvring space for people using wheeled mobility aids to turn in an open, uncrowded space, with good visibility.

However, it may be possible that wheeled mobility aid users could turn in a smaller space when necessary. To explore this, a small-scale validation study was also undertaken as part of the study to understand the turning space capabilities of wheeled mobility aids users within a restricted space and to compare these findings with the manoeuvring space percentiles found from the larger sample (see Section 13.3.3).

13.1 Sample

The analysis in this section is based on a sample of 711 occupied wheeled mobility aids, collected between September 2021 and September 2022 (see Section 12.1 for more

information on the sample). An Interim report was issued to DLUHC in March 2022 (461 sample size) and the data was further analysed in July 2022 (630 sample size).

No significant differences in size were noted across the different data collection sites.

13.2 All wheeled mobility aids

13.2.1 Manoeuvring space requirements: length and breadth

The manoeuvring space percentile measurements for people to turn both 90º and 180º within their wheeled mobility aids is provided in Table 53.

Table 53. Key percentiles for wheeled mobility aid manoeuvring space for a 90º and 180º turn (all wheeled mobility aids).

Percentile	85th	90th	95th	99th
Length of 90° turn (mm)	1945	2084	2255	2630
Breadth of 90° turn (mm)	1936	2066	2225	2671
Length of 180° turn (mm)	2200	2347	2487	2854
Breadth of 180° turn (mm)	2140	2265	2483	3100

Except for a few larger outliers, the use of self-propelled mobility aids had the smallest manoeuvring space measurements for both 90° and 180° turns (see Figure 49 and Figure 50).

For all other wheeled mobility aids, the median space measurements (50th percentile) was larger than the current minimum turning square of 1500 x 1500 mm as set out in ADM Volume 2.

Mobility scooters had a significantly larger turning space measurements than other wheeled mobility aids, with median space dimensions of 1850mm (length) x 2250mm (breadth) for 90° turns, and up to 2350mm (length) x 2700mm (breadth) for the largest mobility scooters to turn 180°.

Those using powered mobility aids generally required more space than self-propelled mobility aids to manoeuvre, but generally used less manoeuvring space than for attendant-propelled mobility aids. This indicates that, overall, turning space dimensions for a wheeled mobility aid user with an attendant will typically be greater than an independent wheeled mobility aid user, even after accounting for larger wheeled mobility aids.

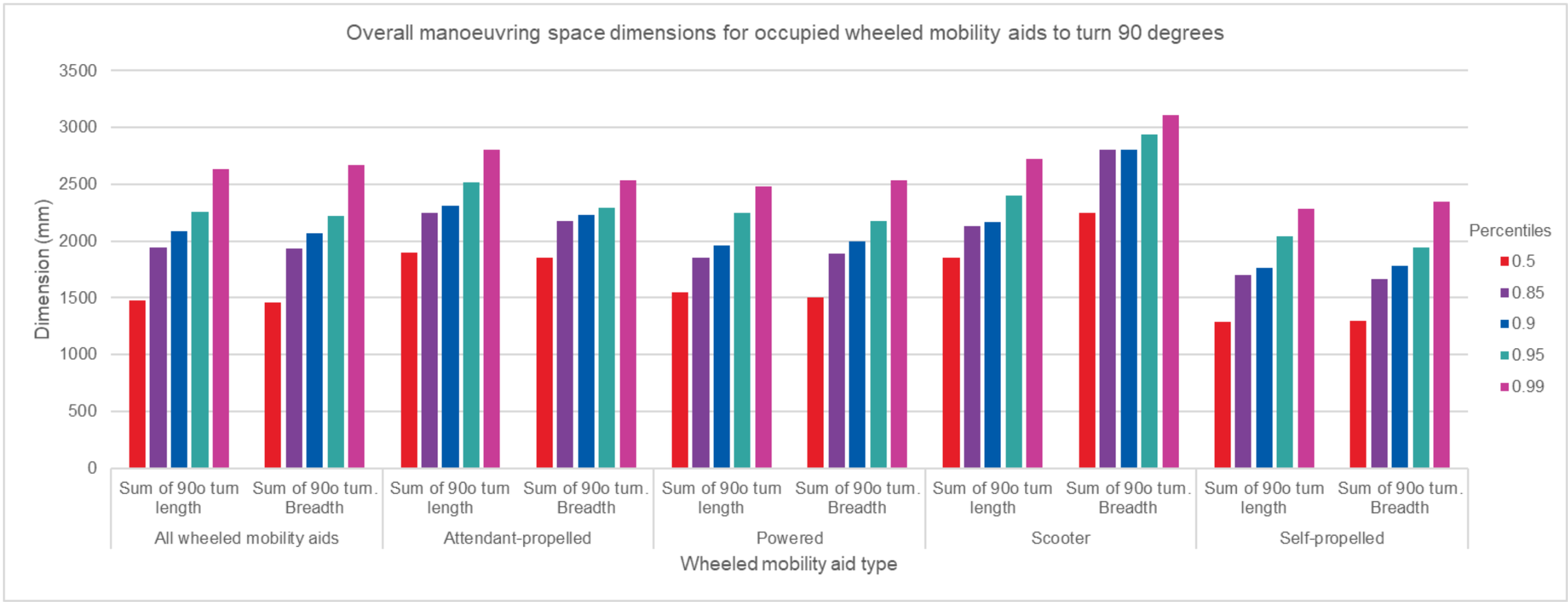


Figure 49. Key percentile length and breadth dimensions for occupied wheeled mobility aid users to turn 90º – by type of wheeled mobility aid.

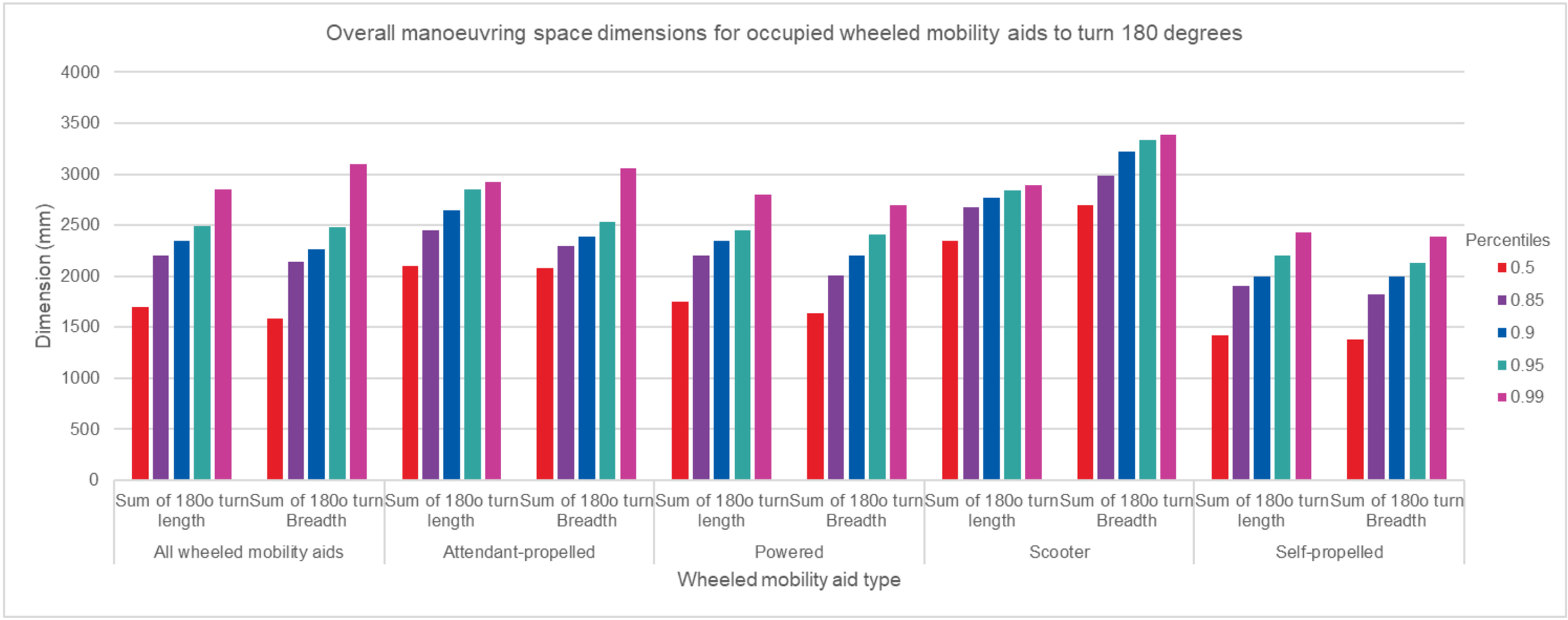


Figure 50. Key percentile length and breadth dimensions for occupied wheeled mobility aid users to turn 180º – by type of wheeled mobility aid.

13.2.2 Manoeuvring square requirements: total area (all wheeled mobility aid types)

The manoeuvring square refers to the total square floor area required for a wheeled mobility aid user (with or without attendant) to complete a turn in their wheeled mobility aid.

The 90th percentile manoeuvring square measurement as used in current ADM Volume 2 is currently 1500mm x 1500mm.

For information on the manoeuvring square percentile measurements for an independent user using a wheeled mobility aid (i.e. without attendant) see Section 13.3.

The manoeuvring square percentile measurements resulting from the study for a user to make a 90° and 180° turn in their wheeled mobility aid are shown in Figure 51 and Figure 52. This has been done by plotting the length against the breadth for each wheeled mobility aid measured.

The 90th percentile manoeuvring square measurement (as used in ADM Volume 2) has been indicated for each dimension with solid red lines on both Figure 51 and Figure 52.

Table 54 sets out the 90th percentile manoeuvring square measurement from the study against current footprint guidance. Other percentile measurements are contained in Section C.2 in Appendix C.

Table 54. Current manoeuvring square guidance against 90th percentile dimensions for all wheeled mobility aids.

Current manoeuvring square guidance (length x breadth)	Source	90° turn (length x breadth) (90th percentile)	180° turn (length x breadth) (90th percentile)
1500mm x 1500mm	ADM Volume 2 Diagram 18	2084mm x 2066mm	2347mm x 2265mm

Note, in a built environment context, the turning square should consist of the largest dimensions for both length and width (i.e. 2084mm x 2084mm or 2347mm x 2347mm).

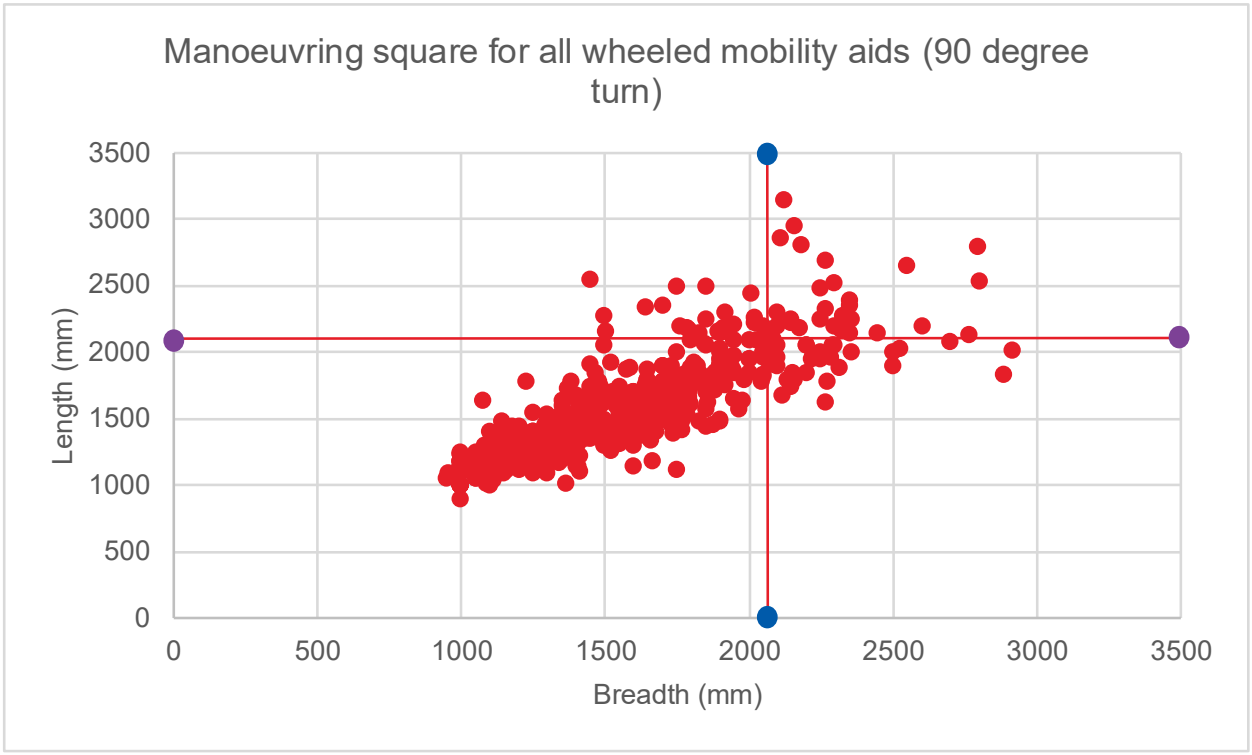


Figure 51. Length and breadth for users to turn 90º in their wheeled mobility aid (all wheeled mobility aids).

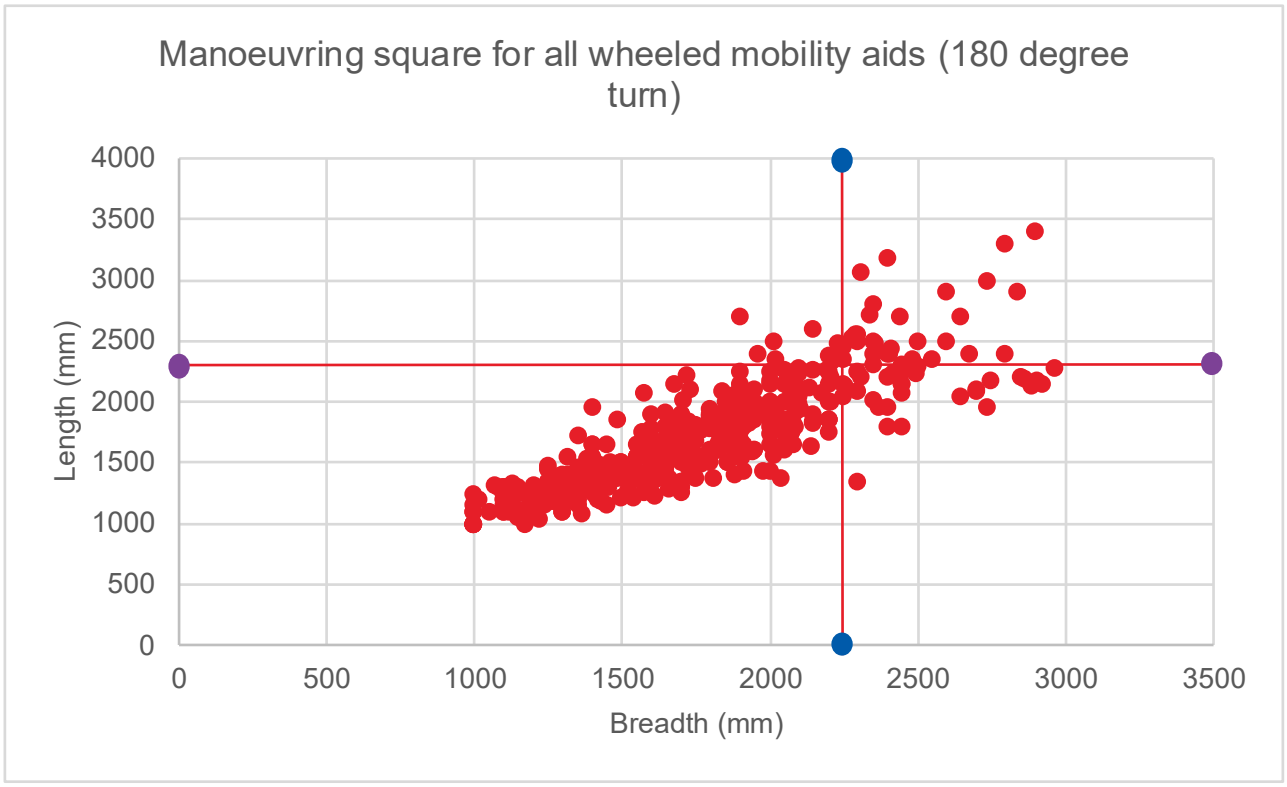


Figure 52. Length and breadth for users to turn 180º in their wheeled mobility aid (all wheeled mobility aids).

13.3 Independent use wheeled mobility aids only

13.3.1 Manoeuvring space requirements: length and breadth

The manoeuvring space percentile measurements for people to turn both 90º and 180º within their wheeled mobility aids is provided in Table 55.

Table 55. Key percentiles for wheeled mobility aid manoeuvring space for a 90º and 180º turn (independent use wheeled mobility aids).

Percentile	85th	90th	95th	99th
Length of 90° turn (mm)	1771	1900	2114	2382
Breadth of 90° turn (mm)	1788	1897	2058	2514
Length of 180° turn (mm)	2050	2200	2400	2743
Breadth of 180° turn (mm)	1950	2095	2311	2700

Except for a few larger outliers, the use of self-propelled mobility aids had the smallest manoeuvring space measurements for both 90° and 180° turns.

For all other wheeled mobility aids, the median space measurements (50th percentile) was larger than the current minimum turning square of 1500 x 1500 mm as set out in ADM Volume 2.

Those using powered mobility aids generally required more space than self-propelled mobility aids to manoeuvre, but generally used less manoeuvring space than for hybrid mobility aids that can be attendant-propelled. This indicates that, overall, turning space dimensions for a hybrid wheeled mobility aid user will typically be greater than wheeled mobility aids aid users using either a powered or self-propelled only mobility aid user.

13.3.2 Manoeuvring square requirements: total area

Manoeuvring space percentile measurements for users of self-propelled and/or powered mobility aids only[44] are provided in Figure 53 and Figure 54. These manoeuvring square percentile measurements may be particularly relevant within spaces for independent use (e.g. wheelchair-accessible toilet).

Table 56 sets out the 90th percentile dimensions. Note, the 90th percentile dimensions were similar to those found at the interim stage (461 sample size) which indicates a robust finding.

[44] For clarity, neither attendant-propelled mobility aids nor mobility scooters are included. However, hybrid wheeled mobility aids that are self-propelled or powered and are also attendant-propelled have been included.

Table 56. Current manoeuvring square guidance against 90th percentile dimensions for independent use wheeled mobility aids).

Current manoeuvring square guidance (length x breadth)	Source	90° turn (length x breadth) (90th percentile)	180° turn (length x breadth) (90th percentile)
1500mm x 1500mm	ADM Volume 2 Diagram 18	1900mm x 1897mm	2200mm x 2095mm

Note, in a built environment context, the turning square should consist of the largest dimensions for both length and width (i.e. 1900mm x 1900mm or 2200mm x 2200mm).

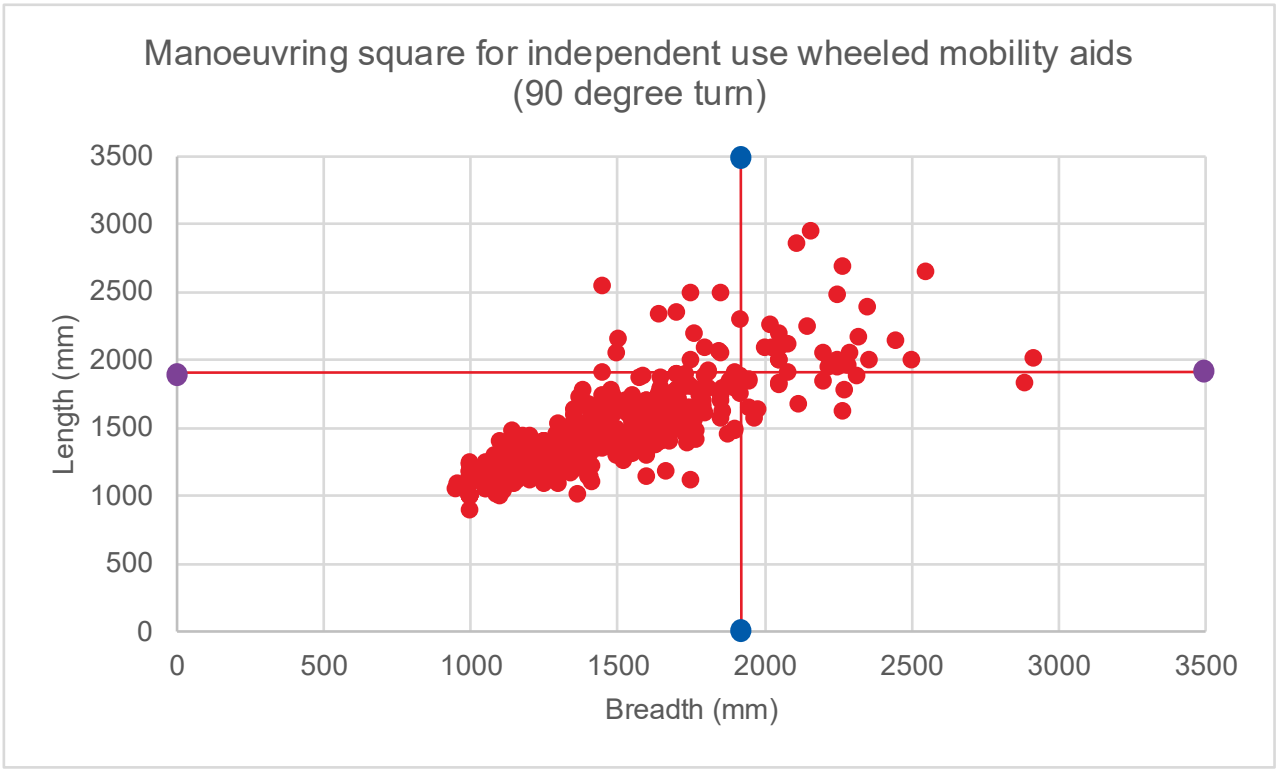


Figure 53. Length and breadth for users to turn 90º in their wheeled mobility aid (independent use mobility aids only).

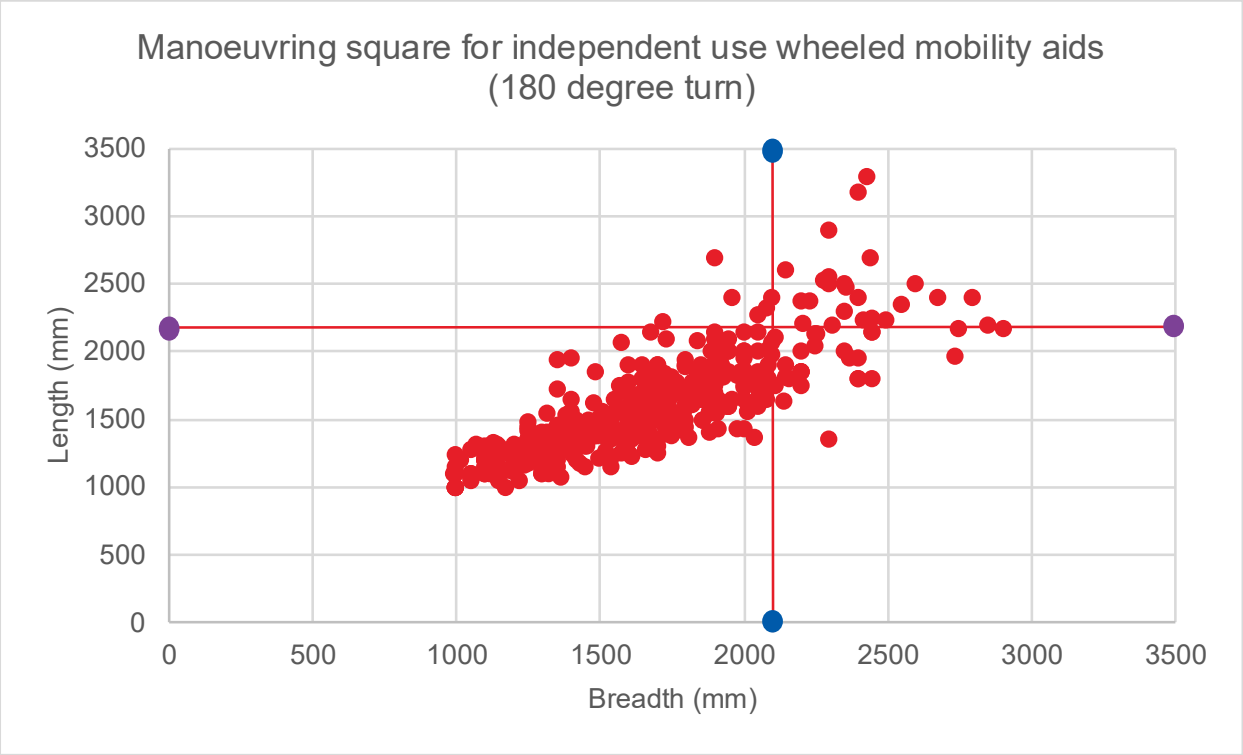


Figure 54. Length and breadth for users to turn 180º in their wheeled mobility aid (independent use mobility aids only).

13.3.3 Manoeuvring square requirements: validation study

To review the manoeuvring square percentile findings for independent use wheeled mobility aids users, a small-scale validation study was undertaken to collect data on participants ability to turn 90º within a confined space.

See Section C.3 in Appendix C for the data collection template for the study.

Method

41 participants took part in the study, consisting of 29 powered mobility aid users and 12 self-propelled mobility aids users.

The space requirements for people to turn both 90º and 180º within their wheeled mobility aids was measured using floor grids. Participants were initially positioned in the measuring grid in their wheeled mobility aid and asked to make a turn in a non-confined space. Length and breadth manoeuvring dimensions were recorded.

Participants then attempted to make a turn in their wheeled mobility aid in a confined space which was confined using cardboard walls. Confined spaces had the following dimensions:

- 1800mm x 1800mm
- 1700mm x 1700mm
- 1600mm x 1600mm
- 1500mm x 1500mm (the current ADM Volume 2 turning space)

The initial dimensions of the confined space were determined by the participants' space requirements for making a turn in a non-confined space (i.e. if the participant completed a

non-confined 90º turn in 1790mm x 1700mm, the starting point for a confined turn was 1800 x 1800mm).

Length and breadth manoeuvring dimensions were recorded, as well as the following for each turn attempted / completed:

- Number of moves for a 90º turn
- Whether the participant made wall contact during the turn and description of the contact
- Participant response when contact was made
- Whether the participant completed the turn
- Participant rating as to the ease or difficulty of completing the turn (using a 5-point Likert scale)

Following a completed turn, the confined space was reduced by 100mm - in both width and length - and the 90 degree turn attempted by the participant in their wheeled mobility aid in the smaller space. Participants completed turns in smaller spaces, until they were no longer able to complete a turn or achieved 1500mm x 1500mm.

Participants were judged unable to complete the turn if one of the following was evident:

- The participant indicated that they could not complete the turn.
- They required greater than a 5-point turn to complete the turn.
- They could not complete the turn without touching the walls (either the user or their wheeled mobility aid).

Key findings: self-propelled mobility aids

Of the 12 participants using self-propelled mobility aids, all 12 completed a turn within a confined space equivalent to their 90º turn dimensions in a non-confined space.

Key finding: powered mobility aids

Of the 29 participants using powered mobility aids, 14 participants completed a turn within a confined space equivalent to their 90º turn dimensions in a non-confined space.

5 participants were unable to achieve turns in their powered mobility aid in the equivalent confined space as expected (compared to the space they required to complete the 90º turn in a non-confined space) all requiring more than 100mm extra than expected to complete the turn.

10 participants made turns in their powered mobility aid in a smaller confined space than expected (compared to the space they required to complete the 90º turn in a non-confined space). Of these, 2 reduced their turn by 50mm or less in one direction, 2 reduced their turn by 100mm or less in one direction, and 2 reduced their turn by 180mm in one direction.

Of the remaining 4 participants, 3 completed a 90º turn in a confined space between 240-290mm less than expected, and 1 completed a 90º turn in a confined space 420mm less than expected, based on their manoeuvring space requirements for the unrestricted turn. All 4 of the participants made their smallest confined turn in 1 movement and rated the turn as very easy.

Research team observations

The following observations were made by the research team conducting the study which should be considered when interpreting these findings:

- When turning in a non-confined space, spatial 'efficiency' in turning was not necessarily a participant priority with no obstructions to consider. For instance, to be able to complete turns in the confined spaces some foot movements were made by participants to enable them to avoid the walls – these foot movements were not needed nor, therefore, made during the non-confined condition.
- In recording 90º and 180º turns in non-confined spaces, users and their wheeled mobility aids were measured as presented on the day. Some participants offered to take off loads (e.g. bags), foot plates etc. if required to turn in a confined space, but this may not be practicable in all real-life instances depending on scenario or location facility being accessed, and thus for the purpose of the experiment, the adaptations were not included.

It is possible the following factors also contributed to the difference in findings between powered and self-propelled mobility aids:

- Users with mid-wheel drive powered mobility aids had an ability to spin on their own footprint which reduced the manoeuvring space required to complete a turn. Some users with powered mobility aids may have less flexibility to undertake a tighter turn depending on the position of the axle of the driving wheels, as wheeled mobility aids will rotate around the centre of their drive wheels.
- Due to the axle position of some powered mobility aids, some users had to make a forward movement, away from the starting position, in the corner of the space, before turning, requiring additional space.
- Some users in powered mobility aids made small reverse actions with the turn resulting in more than 5 movements. However it was not possible to accurately record the number of these movements due to the speed or size of movement.

Conclusion

Given the small-scale sample, it is not possible to conclude that the findings are more representative of the manoeuvring space measurements of the wider population of wheeled mobility aid users than the 90th percentile manoeuvring space measurements of wheeled mobility aid users in the larger study (see Section 13.2.2 and 13.3).

It should be noted that the 90th percentile manoeuvring space measurements recorded for the non-restricted 90º turn in the larger study (711 sample size) were also similar to the those obtained at the interim stage of the study (461 sample size) suggesting a robustness to the findings.

Participants who exceeded expectations and managed smaller turning circles in this study - all users with powered mobility aids - their turning ability appeared highly dependent on the individual wheeled mobility aid model and its turning capabilities. This is likely to be consistent for users with powered mobility aids sampled as part of the larger scale study.

Personal driving and manoeuvring style may also impact on the user's ability to turn within the expected percentile dimensions.

13.4 Comparison to existing research and standards

Table 57 summarises key dimensions in existing guidance and sets out what percentage of occupied wheeled mobility aids measured in the experimental study would be accommodated by each dimension.

The key dimensions from ADM are:

- Turning square for a wheeled mobility aid user (with or without attendant) to complete a turn (90º or 180º) in their wheeled mobility aid: 1500mm x 1500mm.
- 'Footprint' of a stationary, occupied mobility aid: 900mm (width) x 1400mm (length).

For ease of reference, the percentages have been coloured red, amber and green.

- Red cells indicate that current dimensions will accommodate **less than 50%** of wheeled mobility aids in the relevant category
- Amber cells indicate that they will accommodate **50-90%** of wheeled mobility aids in the relevant category
- Green cells indicate that they will accommodate **more than 90%** of wheeled mobility aids in the relevant category.

These dimensions are demonstrated to reflect the dimensions shown in current guidance which includes:

- A turning space
- Door width
- Although a footprint is not shown on plan, current diagrams (e.g. in ADM Volume 2) do demonstrate a wheeled mobility aid in the transfer space beside the toilet area, and ADB include space for a refuge space to accommodate a wheelchair user.

Table 57. Key dimensions in existing guidance and percentage of occupied wheeled mobility aids accommodated.

Item	Dimension	Reference	Study data			
			Percentage of all wheeled mobility aids included	Percentage of self-propelled wheeled mobility aids included	Percentage of attendant-propelled wheeled mobility aids included	Percentage of powered wheeled mobility aids included
Footprint of stationary occupied wheeled mobility aid[45]	900mm width (including widest part of the user)	ADM Volume 2 3.43g, 4.12g	93.0%	92.9%	83.8%	94.9%
	1400mm length (without attendant)	ADM Volume 2 3.43g, 4.12g	82.6%	92.0%	71.8%	75.4%
Turning square – 90° turn[46]	1500mm length	ADM Volume 2 Diagram 18	42.8%	62.0%	12.8%	34.5%
	1500mm width	ADM Volume 2 Diagram 18	45.0%	63.3%	12.0%	39.3%
Turning square – 180° turn	1500mm length	ADM Volume 2 Diagram 18	27.1%	46.8%	5.1%	16.0%
	1500mm width	ADM Volume 2 Diagram 18	35.4%	54.5%	6.8%	27.8%
Door width	800mm (internal circulation for new build)	ADM Volume 2 Table 2	72.7%	67.7%	60.0%	78.4%
	1000mm (entrance door)	ADM Volume 2 Table 2	97.5%	98.7%	91.8%	97.7%

[45] This dimension represents the space required for a stationary occupied wheeled mobility aid. The dimension is cited in various clauses of ADM, including the minimum size of a lifting platform and the space required for a parked wheelchair in a performance venue.

[46] It is not clear from ADM what type and method of turn is to be accommodated by the 1500 x 1500 mm turning circle. For this report, it is compared to the data obtained from the study for both a 90º and 180° turn.

13.5 Summary and key findings

The photogrammetric survey aimed to collect experimental data on the percentile manoeuvring space measurements of wheeled mobility aids completing both a 90º and 180º turn.

The key findings are:

- Users of different types of wheeled mobility aid have different manoeuvring space measurements. This is primarily due to way the mobility aid is designed and used which is likely to be determined by the user's needs. For instance, a user with a mid-wheel drive powered mobility aid may be able to spin on their own footprint which will reduce the manoeuvring space required to complete a turn.
- Manoeuvring space measurements may also be impacted by the adaptations or additions to the wheeled mobility aid (e.g. bags, foot plates etc.) which may be fixed or removeable and vary at different times.
- The 90th percentile manoeuvring measurements in a non-restricted space for all wheeled mobility aids in this study was 2084mm x 2066mm (length x breadth to make a 90º turn).
- For independent use wheeled mobility aids only, the 90th percentile manoeuvring measurement in a in a non-restricted space was 1900mm x 1897mm (length x breadth to make a 90º turn).
- Therefore, the findings from this study indicate that the current spatial guidance to accommodate a user to turn in their wheeled mobility aid ('turning space') in ADM Volume 2 (i.e. minimum dimensions of 1500mm x 1500mm (length x width)) - would be too small to accommodate most wheeled mobility aid users.
  - In this study, only 42% of users (all wheeled mobility types) were able to turn 90º in the 1500mm x 1500mm ADM Volume 2 requirements (reducing to 27% for a 180º turn).
  - Considering wheeled mobility aids individually, self-propelled mobility aids were generally more likely to be able to turn 90º within the 1500mm x 1500mm ADM Volume 2 requirements (62%) (reducing to 46% for a 180º turn). Attendant-propelled mobility aid were less likely to be able to turn 90º within the 1500mm x 1500mm ADM Volume 2 requirements (12%) (reducing to 5% for a 180º turn).
- It is possible that some wheeled mobility aid users could turn using smaller dimensions if required to turn in a confined space, but this would likely be highly dependent on the individual wheeled mobility aid model and its turning capabilities, as well as the personal driving and manoeuvring style of users. To complete tighter turns, users may also be required to remove loads (e.g. bags, footplates etc.) and make more complex movements to complete the turn than if able to turn freely.

14. Objective 3: Focus studies

Several focus studies were undertaken to understand to collect quantitative data relevant to key activities within the built environment, including the reach ranges for everyday activities, opening forces, motor skills, strength and space required to open and use doors window and operate buttons and suitable ramp gradients for wheeled mobility aid users and ambulant disabled people.

The studies focused on three key Research Streams:

- The reach ranges for people in wheeled mobility aids, specifically looking at reach ranges for everyday activities such as posting and picking up letters and reaching switches and sockets to operate controls to understand how this compares to current guidance (see Section 15).
- The opening forces, motor skills, strength and space required to open and use doors, windows and operate buttons and to understand how this compares to current guidance (see Section 16).
- The tipping points of unoccupied and 'occupied' wheeled mobility aids on ramps and slopes and disabled people's experience of using ramps (see Section 17).

All experimental data was collected by a research team from Loughborough University (LU).

LU has strict data protection rules for research activity and all data collected for the study was subject to LU's internal ethical review process / approvals process and associated communication protocols to the participants.

The studies were important to establish the most current data for England, and to understand how this compares to the current spatial standards for the built environment.

15. Research Stream 10: Reach

This quantitative research focus study aimed to collect experimental data on reach ranges for people in wheeled mobility aids, specifically looking at reach ranges for everyday activities such as posting and picking up letters and reaching switches and sockets to operate controls to understand how this compares to current guidance.

15.1 Data constraints

To ensure the data collected as part of this study is comparable to previous data points, we have applied a trigonometry calculation to extrapolate the data at the angles previously used in BS 8300-2:2018.

It is unclear why these data points were previously used by BS 8300-2:2018, as this does not reflect the angles reachable by individuals or provide an overall picture of reach ranges. This is explained further in the method section of this report (see Section 15.3). Further data caveats are detailed in Section 15.3.2.

15.2 Current design guidance on reach ranges

Current guidance documents BS 8300-2:2018 and ADM (Volumes 1 and 2) provide some recommendations on reach ranges for the built environment.

15.2.1 BS 8300-2:2018

Reach ranges

BS 8300-2:2018 Section E.2 details reach ranges for both comfortable and extended reach ranges:

- **Comfortable** reach range– determined by the capability of a person to comfortably reach for something, in a relaxed manner without needing to stretch to reach and perform an activity. Comfortable reach ranges are recommended where a task requires precision or is frequently performed.
- **Extended reach range** – determined by the capacity of a person to reach when stretching and / or bending the body and deemed appropriate for activity that does not require precision and is infrequently performed.

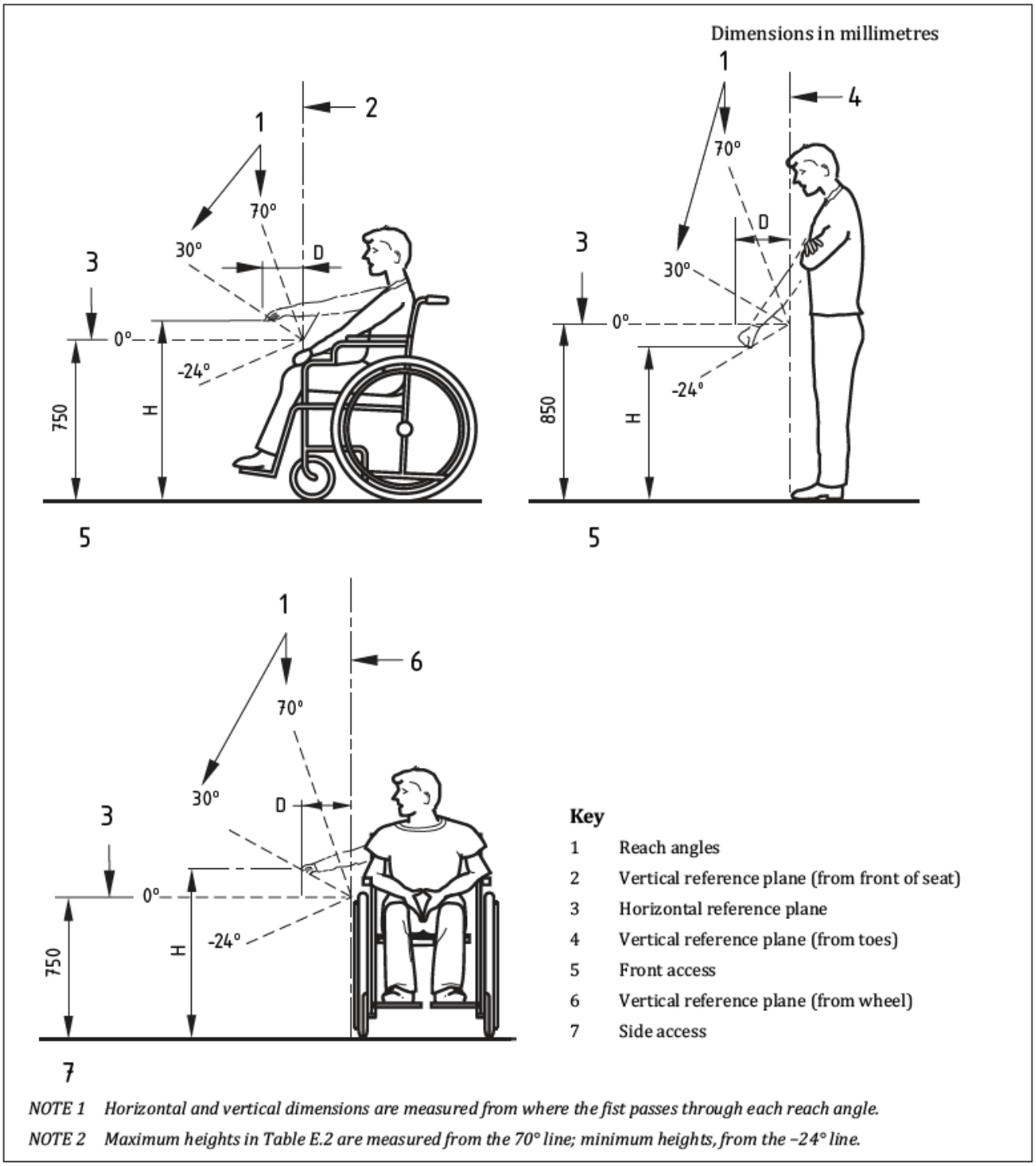
The dimensions shown in Table 58 represent the reach capabilities of 90% of the sample of wheelchair users and ambulant disabled people who took part in the trial for BS 8300-2:2018 (sample number not known). Figure 55 is the visualisation of the data presented in Table 58.

Table 58. Reach ranges from section E.2 BS 8300-2:2018.

Person	Access	Reach angle	Height (H)		Depth (D)	
			Comfortable mm	Extended mm	Comfortable mm	Extended mm
Wheelchair user	Front	+ 70° Horizontal -24°	1000 (750) 650	1150 (750) 650	90 180 120	120 230 200
	Side	+ 70° Horizontal -24°	1060 (750) 665	1170 (750) 630	100 220 165	135 310 230
Ambulant disabled	Front	+ 70° Horizontal -24°	1500 (850) 700	1625 (850) 700	200 280 180	250 450 310

() = horizontal reference plane

Figure E.3 — *Reference planes, reach angles and definition of height/depth*



NOTE 1 *Horizontal and vertical dimensions are measured from where the fist passes through each reach angle.*

NOTE 2 *Maximum heights in Table E.2 are measured from the 70° line; minimum heights, from the –24° line.*

Figure 55. Diagram showing reach ranges as per E.3 BS 8300-2:2018 © British Standards Institute.

Plug sockets

BS 83002:2018 paragraph 15.7.2 details the position of outlets, switches, controls and meters:

- Electrical wall sockets should be located between 400mm – 1000mm from finish floor level (FFL) – note this is the vertical distance from floor level to the item of note.
- Sockets that are likely to be removed and replaced regularly should be located at the top of this range.
- Permanently wired sockers can be mounted at a range of 750mm - 1200mm from FFL.
- Outlets and switches and controls should be placed at least 350mm from room corners.

Figure 18 — *Heights to the centre of outlets, switches and controls*

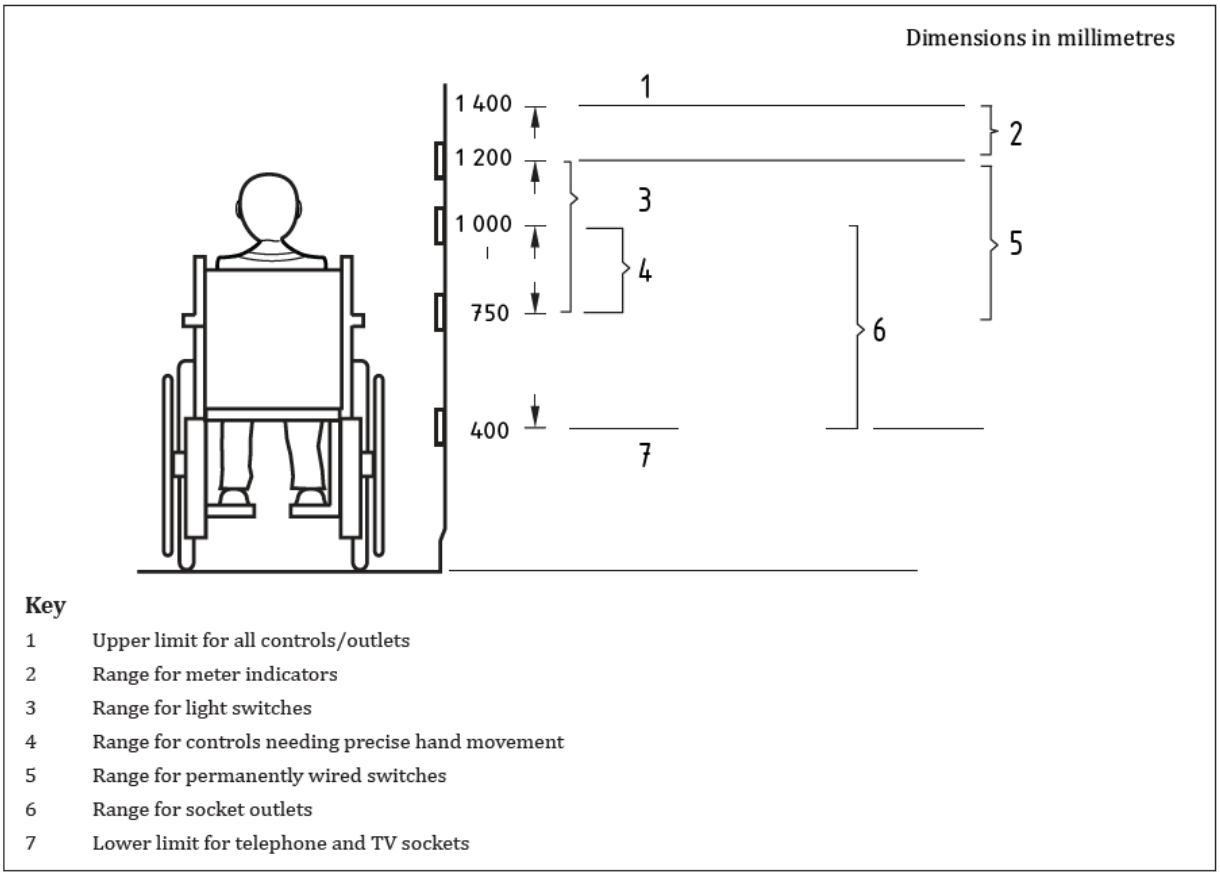


Figure 56. Heights to centre of outlets, switches and controls as per figure 18 BS 8200-2:2018 © British standard institute.

15.2.2 Approved Document M (ADM)

ADM has various clauses and detailed guidance for reach ranges for different components. The below details the information contained with in both Volume 1 (for wheelchair users only) and Volume 2 of ADM. It is noted that Volume 1 provides more detailed guidance on reach ranges. Specific detail on letter boxes has also been included.

Approved Document M Volume 1 (for dwellings):

Clause 3.44 details guidance for M4(3) Category 3: Wheelchair user dwellings (i.e., dwellings that are designed for wheelchair users):

- Switches, sockets and stopcocks and controls should be located with their centre line 700-1000mm above FFL and a minimum 700mm (measured horizontally) from an inside corner.
- Handles for windows should be between 450mm-1200mm above FFL unless fitted with remote opening device in this range. Switches, sockets, doorbells, entry phones, light switches, power sockets, TV ariel and telephone jacks serving habitable rooms, should have their centre line 450mm – 1200mm above finished floor level.
- Door handles, locks and latches should be easy to grip and fitted between 850-1000mm above FFL.
- Boiler timer and controls should be mounted 900-1200mm above FFL on the boiler or separate controllers (wired or wireless) mounted elsewhere in an accessible location within this height range.
- Radiator controls should be mounted 450-1000mm above FFL.
- Letter boxes
  - Door nibs should allow for the fitting of a letter cage to the inside face of the letter box.
  - Currently there is no set guidance on letter box height. However, in 2019 the government backed the campaign by postal unions to ban low level letter boxes from new buildings[47]. Though not confirmed it has been suggested that the height of letterboxes would be set to follow European standards of between 700mm – 1700mm FFL[48].

Approved Document M Volume 2 (for buildings other than dwellings):

Clause 4.30 details for switches, outlets and controls:

- Wall mounted sockets and telephone points between 400mm and 1000mm above FFL.
- For permanently wired appliance located between 400 – 1200mm from FFL.
- Switches that require precise hand movements located between 750mm – 1200mm FFL.
- Any push button controls that require limited dexterity are no more than 1200mm FFL.
- Sockets are no nearer than 350mm from corner of a room.

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[47] "Low-level Letter Boxes (Prohibition) Bill," 6 March 2019 . [Online]. Available: https://bills.parliament.uk/bills/2336.

[48] BBC, "Low-level letter boxes set to be banned in 'victory' for posties," 5 March 2019. [Online]. Available: https://www.bbc.co.uk/news/uk-politics-47457758. [Accessed 28 September 2022].

15.3 Methodology

The study used a mix of photogrammetric methods for data collection (following the same methodology used for the Objective 2b research).

In summary, it involved taking calibrated photographs and using them to calculate precise dimensions) and manual measurements with a measuring tape by researchers following a standardised method (as detailed in Table 59).

Participants were asked to sit in their wheelchair with a temporary wall placed around them to simulate walls and corners within a built environment. Participants were asked to reach in various planes, involving movement / no movement of their trunk. Measurements were taken by researchers and recorded – from this is has been possible to calculate percentiles to provide recommendations on reach ranges.

Figure 57. Example of straight down reach - no trunk movement (vertical height) measurement being taken by LU research team.

15.3.1 Data collection refinement

The original methodology for reach range data included reach ranges / envelopes for forward and down, and directly down from the shoulder. Following reflection of the initial data collected, the Loughborough research team refined the measurements taken to better align with and allow comparison to how people use spaces. This was revised to include forward reach horizontal, lateral reach horizontal, vertical downward reach and vertical upward reach, all with and without trunk movement. This has provided a much larger set of observations allowing better comparison to current guidance. Due to some of these data

collection points being added later in the research, the data sets are in some cases smaller than those collected throughout the remainder of the project.

15.3.2 Data Caveats

Zero / footprint point

In order to standardise the measures a reference point was created – this was the most forward part of the person, or their chair projected down to the floor. This point has been noted as the footprint or '0 point'. However, in analysing the data in particular for horizontal measures the data collected the data was reanalysed to allow the 0 point to be the front edge of a chair to align better with how data is presented in BS 8300-2:2108. This did not pose an issue for any lateral measurements as these used the side of the chair as the reference point.

When reading measurements for horizontal some minus numbers are shown due to requiring a 0 point and the ranges of movement shown in participants of the study.

For the following measurements in this report the following sections show minus numbers

- Horizontal reach horizontal measure, no trunk movement (NTM)
- Angled plug reach horizontal height, no trunk movement (NTM)
- Horizontal reach horizontal measure, with trunk movement (TM)
- Angled plug reach horizontal measure, with trunk movement (TM)
- Straight down reach horizontal height, no trunk movement (NTM)
- Straight down reach horizontal height, with trunk movement (TM)

Where this is the case the percentiles with minus numbers represent those who could not reach beyond the front edge of their chair and the measurement is the dimension from the front edge of the chair back to the hand. Where positive numbers are shown this is the distance advancing away from the front edge of the chair to the knuckle of the hand.

Vertical measurement caveats

For the vertical measurements which focused on the lower reach ranges in the following sections:

- Angled plug reach vertical height, no trunk movement (NTM)
- Angled plug reach vertical height, with trunk movement (TM)
- Straight down reach vertical height, no trunk movement (NTM)
- Straight down reach vertical height, with trunk movement (TM)- measured from the side

The measurements have been reversed when reporting in the percentile tables later in this report. This is because those closer to the floor will present a smaller dimension but represents those with a longer reach. Where this is the case, it has been detailed in Table 59.

No trunk movement vs. trunk movement

Note that for the data collected vertical measurements (the distances between the arm and FFL) for forward reach and side reach with no trunk movement were greater than that of the forward and side reach data with trunk movement. For extended ranges this is due to the engagement of the trunk and so reaching both forward and laterally may cause the shoulder to drop causing a lesser distance between the arm and FFL. This has resulted in the extended reach ranges being reported as less than the comfortable reach ranges.

Calculation for Upper (+70°) & lower reach (- 24°) ranges

Due to the method for the data as collected in BS 8300-2:2018 being unknown, to replicate the -24° & +70° degree measurement reported in this guidance a calculation was carried out by the Loughborough University research team based on the findings from this study it is noted that though this allows some comparisons to be made, it cannot be treated as a full / direct comparison as the methodology of the data from BS 8300 is unknown. The results for this are detailed in Table 66.

Horizontal plane

It is also noted that due to the unknown origin of the BS 8300-2:2018 data as highlighted above that we have reported the horizontal plane data for both the 5th and 50th percentile findings from this study for transparency in Table 66 &

Table 67.

Equation detail for Front & Side height and depth

In the below the numbers such as 13a represent the number as per the first column in Table 59.

Front reach - Height Comfortable

- +70° calculation. Vertical distance = 13a + (16a x Sin 70)
- -24° calculation. Vertical distance = 13a - (16a x Sin 24)

Front reach - Height Extended

- +70° calculation. Vertical distance = 14a + (16a x Sin 70)
- -24° calculation. Vertical distance = 14a - (16a x Sin 24)

Arm out to side - Height Comfortable

- +70° calculation. Vertical distance = 16a + (16a x Sin 70)
- -24° calculation. Vertical distance = 16a - (16a x Sin 24)

Arm out to side - Height Extended

- +70° calculation. Vertical distance = 16c + (16c x Sin 70)
- -24° calculation. Vertical distance = 16c - (16c x Sin 24)

Front Reach - Depth Comfortable

- +70° calculation. Horizontal Reach. 13b - Lost reach = 13b - (16a - (16a x Cos 70)).
- -24° calculation. Horizontal Reach. 13b - Lost reach = 13b – (16a - (16a x Cos 24))

Front Reach - Depth Extended

- +70° calculation. Horizontal Reach. 14b – lost reach = 14b - (16a - (16a x Cos 70)).
- -24° calculation. Horizontal Reach.14b – lost reach = 14b – (16a - (16a x Cos 24))

Arm out to side Depth Comfortable

- +70° calculation. Horizontal Reach. = (16b x Cos 70)
- -24° calculation. Horizontal Reach. = (16b x Cos 24)

Arm out to side Depth Comfortable

- +70° calculation. Horizontal Reach. = (16d x Cos 70)
- -24° calculation. Horizontal Reach. = (16d x Cos 24)

The below shows an example of the two measures used to work out the front reach height – comfortable.

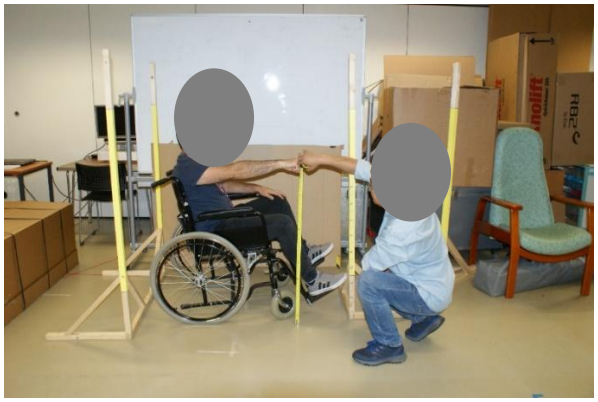
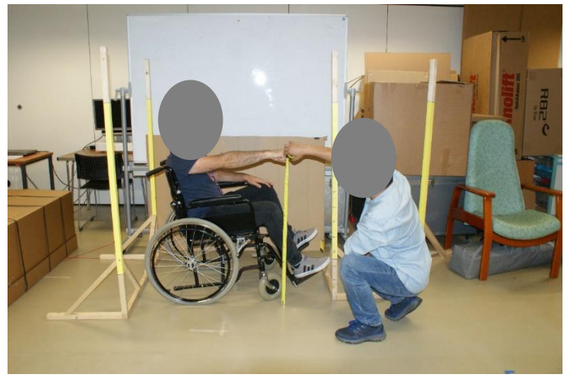
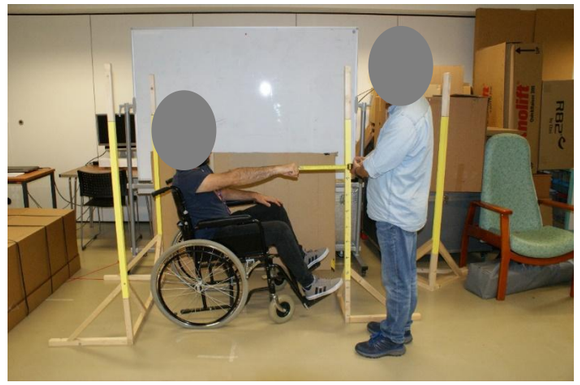


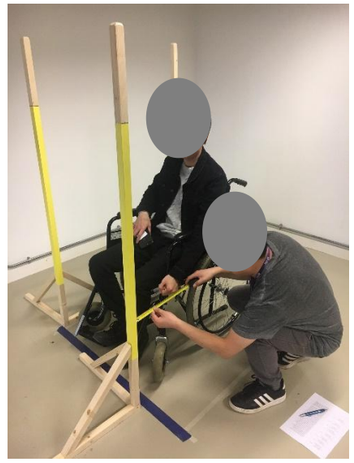
Figure 58. Example of horizontal reach - no trunk movement (NTM) vertical (13a) measurement (left image) and lateral reach to side – no trunk movement (NTM) vertical (16a) (right image).

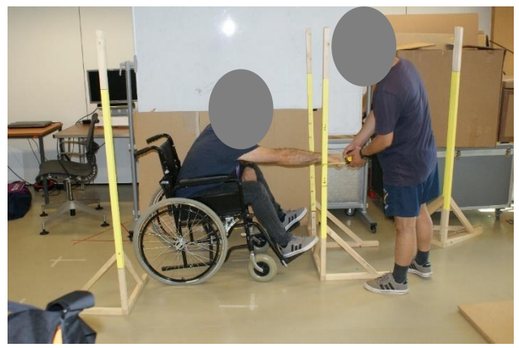
15.3.3 Study measurements

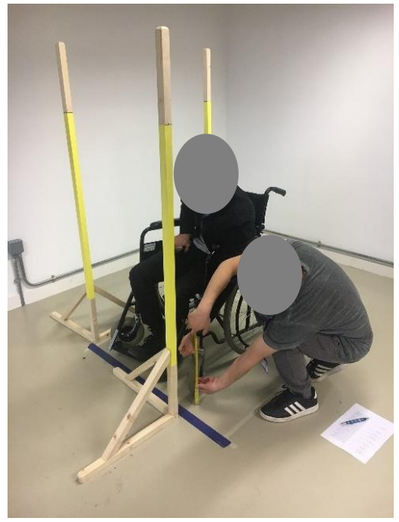
Table 59 details the measurements that were taken to inform this study.

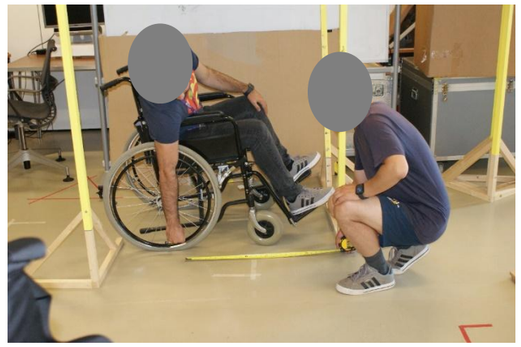
Table 59. Measurements taken in reach range study.

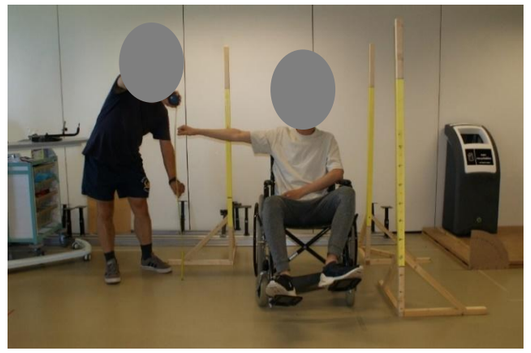
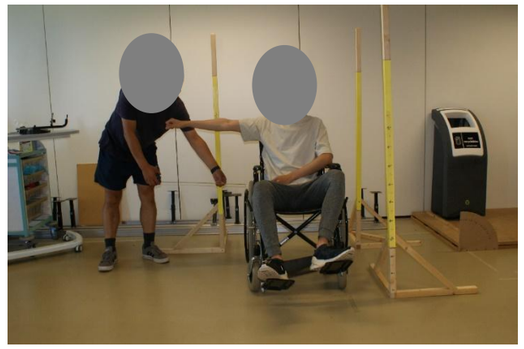
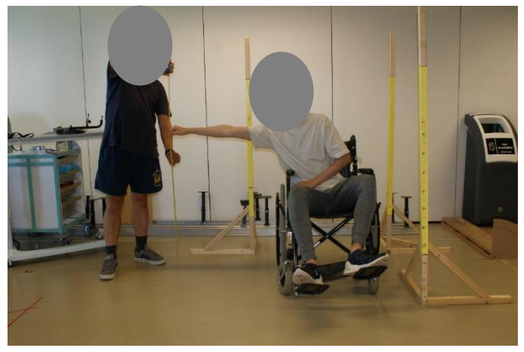
Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
13a	Horizontal reach No trunk movement (NTM) Shoulder (Vertical height measure)	With the wheelchair placed against a facing wall. The occupier stays in sitting, reaches forward as far as they can to find the most distant position. Measure height floor to middle finger knuckle (vertical)	Looks at distance between the floor and the hand of a seated user (for comfortable forward reach range from FFL and horizontal plane reference)	
13b	Horizontal reach No trunk movement (NTM) Shoulder (Horizontal Measure)	With the wheelchair placed against a facing wall. The occupier stays in sitting position, reaches forward as far as they can to find the most distant position. Measure from wall to middle finger knuckle (horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between the wall and the hand of a seated user when front of chair is the closest possible to a wall (for comfortable forward reach range from wall)	
One 13c	Angled Plug reach No trunk movement (NTM) Reach (Vertical Height)	With the wheelchair placed against a facing wall. The occupier stays seated, reaches forward and down as far as they can to find the most distant position. Measure height floor to middle finger knuckle (vertical) Note this is a measurement where percentiles have been reversed as closer to the floor will present a smaller dimension but represents those with a longer reach	Looks at distance between a floor and the hand of a seated user (for comfortable lower forward reach range)	

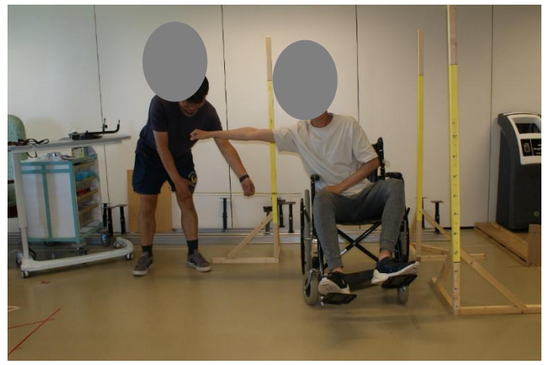
Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
13d	Angled Plug reach No trunk movement (NTM) Reach (Horizontal Measure)	With the wheelchair placed against a facing wall. The occupier stays seated, reaches forward and down as far as they can to find the most distant position. Measure from wall to middle finger knuckle (Horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between a wall and the hand of a seated user when front of chair is the closest possible to a wall (for comfortable lower reach range from corner)	
13.1c	Straight Down Reach No Trunk Movement (NTM) (Vertical Height)	With the wheelchair placed against a facing wall. The occupier stays seated, reaches down from the shoulder. Measure height floor to middle finger knuckle (vertical) Note this is a measurement where percentiles have been reversed as closer to the floor will present a smaller dimension but represents those with a longer reach	Looks at distance between the floor and the hand of a seated user (for comfortable lower mounting height & comfortable lower side reach)	

Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
13.1d	Straight Down Reach No Trunk Movement (NTM) (Horizontal Measure)	With the wheelchair placed against a facing wall. The occupier stays seated, reaches down from the shoulder. Measure from wall to middle finger knuckle (horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between a wall and the hand of a seated user when front of chair is the closest possible to a wall (for comfortable reach range from corner with hand in neutral position)	
14a	Horizontal reach With trunk movement (TM) Shoulder (Vertical Height)	With the wheelchair placed against a facing wall. The occupier can lean forward whilst seated, reaching forward as far as they can to find the most distant position. Measure height floor to middle finger knuckle (vertical)	Looks at distance between the floor and the hand of a seated user (for extended forward reach range from FFL)	
14b	Horizontal reach With trunk movement (TM) Shoulder Horizontal	With the wheelchair placed against a facing wall. The occupier can lean forward whilst seated, reaching forward as far as they can to find the most distant position. Measure from wall to middle finger knuckle (Horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between the wall and the hand of a seated user when front of chair is the closest possible to a wall (for extended forward reach)	

Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
14c	Angled Plug reach With trunk movement (TM) Reach Vertical height	With the wheelchair placed against a facing wall. The occupier can lean forward whilst seated, reaching forward and down as far as they can to find the most distant position. Measure height floor to middle finger knuckle (vertical) Note this is a measurement where percentiles have been reversed as closer to the floor will present a smaller dimension but represents those with a longer reach	Looks at distance between a floor and the hand of a seated user (for extended lower forward reach range)	
14d	Angled Plug reach With trunk movement (TM) Reach Horizontal	With the wheelchair placed against a facing wall. The occupier can lean forward whilst seated, reaching forward and down as far as they can to find the most distant position. Measure from wall to middle finger knuckle (horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between a wall and the hand of a seated user when front of chair is the closest possible to a wall (for extended lower reach range from corner)	 Note with trunk movement

Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
14.1c	Straight Down Reach With trunk movement (TM) Vertical height	With the wheelchair placed against a facing wall. The occupier can lean forward in sitting, reaches down from the shoulder. Measure height floor to middle finger knuckle (vertical) Note this is a measurement where percentiles have been reversed as closer to the floor will present a smaller dimension but represents those with a longer reach	Looks at distance between the floor and the hand of a seated user (for comfortable lower mounting height & extended lower side reach)	
14.1d	Straight Down Reach With trunk movement (TM) Horizontal Measure	With the wheelchair placed against a facing wall. The occupier can reach forward in sitting, reaches down from the shoulder. Measure from wall to middle finger knuckle (horizontal) Note this is a measurement where percentiles have been reanalysed to have a 0 point of the front edge of the chair so minus numbers are present in the data set	Looks at distance between a wall and the hand of a seated user when front of chair is the closest possible to a wall (for extended reach range from corner with hand in neutral position)	
15	Arm Highest Reach	Maximum middle finger knuckle height (from FFL) with the person sat in their wheelchair	Maximum reachable height for seated user (caveat that in principle it is not likely a person will ever be reaching for an item in this position- the arm will often be placed in front reach forward and up)	

Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
16a	Lateral reach to side No trunk Movement (NTM) Vertical measure	Person reaches out to side, measure distance from floor to middle finger knuckle	Distance between arm when stretched out and the floor (used for side reach ranges)	
16b	Lateral reach to side No trunk movement (NTM) Horizontal measure	Person reaches out to side, measure horizontal distance from edge of wheelchair to middle finger knuckle	Distance between arm when stretched out and the floor (used for reach ranges in corners where wheelchair is in line with the wall from the front)	
16c	Lateral reach to side With Trunk Movement (TM) Vertical measure	Person reaches out to side, measure distance from floor to middle finger knuckle	Distance between arm when stretched out and the floor (used for extended side reach ranges)	

Number (as per equation calculations)	Measurement	Description	Application of measurement to the built environment	Photograph
16d	Lateral reach to side With Trunk Movement (TM) Horizontal measure	Person reaches out to side, measure horizontal distance from edge of wheelchair to middle finger knuckle	Distance between arm when stretched out and the floor (used for extended reach ranges in corners where wheelchair is in line with the wall from the front)	

15.3.4 Sample

Measurements regarding reach ranges were taken as part of the wider data collection for this Part M research project. All participants in the research for reach ranges were wheelchair users. This data is a small-scale ergonomic research study with the intention to provide comparisons to the current recommendations included in BS 8300-2:2018. Full details of the number of participants per reach range question are detailed in Table 60.

The sample sizes vary for different collections, depending on what the participants wanted to contribute to. We have noted the numbers in the data tables for transparency.

Data points collected were refined by LU during the research (see Section 15.3.1) hence lower participant numbers are recorded for some measurements.

Table 60. Participant totals for specific study measurements.

Plug and letter box specific data	Number of Participants
Horizontal reach No trunk movement (NTM) Shoulder (Vertical height measure)	372
Horizontal reach No trunk movement Shoulder (Horizontal measure)	372
Angled plug reach No trunk movement Reach (Vertical Height)	198
Angled plug reach No trunk movement Reach (Horizontal measure)	198
Straight Down Reach No Trunk Movement (Vertical Height)	176
Straight down reach No trunk movement (Horizontal Measure)	176
Horizontal reach With trunk movement	368

Plug and letter box specific data	Number of Participants
Shoulder (Vertical height)	
Horizontal reach With trunk movement Shoulder horizontal	368
Angled plug reach With trunk movement Reach vertical height	195
Angled plug reach With trunk movement Reach horizontal	195
Straight down reach With trunk movement Vertical height	176
Straight down reach With trunk movement Horizontal measure	176
Arm highest reach	175
Lateral reach to side No trunk movement Vertical measure	175
Lateral reach to side No trunk movement Horizontal measure	175
Lateral reach to side With trunk movement Vertical measure	174
Lateral reach to side	174

Plug and letter box specific data	Number of Participants
With trunk movement Horizontal measure	

15.4 Plug socket data findings

The following section provides a summary of the findings in relation to reach ranges for plug sockets. All measurements were collected in centimetres (cm) but have been reported in both cm and millimetres (mm) for ease for comparison to current standards. The data presented in the tables has been rounded to the nearest 1 decimal place. See Section D.1 in Appendix D for the raw data tables.

The results have been split into those incorporating:

- No trunk movement which could be used for more generous 'comfortable' reach ranges
- Trunk movement for the extended reach range for activities that do not need to be performed on a regular basis

For this study the 5th, 50th, and 95th percentile data has been identified for comment / comparison, however within the data sets presented in the tables the 80th, 85th, 90th and 99th are also available.

In the case of reach range, it is advised that in most cases (unless otherwise stated) the 5th or 95th percentile measurement is used as this will indicate the reach range for the lowest 5th percentile of the data set and total 95th percentile of a data set (only excluding the top and bottom 5th percentile). Designing to the 5th percentile accounts for the smallest 5% of a data set which is useful when considering maximum reach heights. Designing to the 95th percentile is beneficial when considering the lowest possible reach range height. In the case of plug socket data analysis, this looks mainly at lower reach ranges therefore the 95th percentile has been used. It is common practice that anthropometric data is split by sex. In the case of the data set collected for this report sex was not recorded and data sets have been analysed as a whole - however the data analysis reports on the ranges and difference that may be presented due to sex.

Note, as explained in Section 15.3.2, for horizontal measurements where it is the case the percentiles with minus numbers represent those who could not reach beyond the front edge of their chair and the measurement is the dimension from the front edge of the chair back to the hand. Where positive numbers are shown this is the distance advancing away from the front edge of the chair to the knuckle of the hand.

15.4.1 No trunk movement (NTM)

The below details the data findings for reach ranges with no trunk movement (NTM).

Table 61. No trunk movement - plug reach percentile data.

Percentile Raw	Horizontal reach (cm) No trunk movement (NTM) Shoulder (Vertical height measure)	Horizontal reach (cm) No trunk movement (NTM) Shoulder (Horizontal measure)	Angled Plug reach (cm) No trunk movement (NTM) Reach (Vertical height)	Angled Plug reach (cm) No trunk movement (NTM) Reach (Horizontal measure)	Straight Down Reach (side) (cm) No trunk movement (NTM) (Vertical height)	Straight Down Reach (side) (cm) No trunk movement (NTM) (Horizontal measure)
5	50.0	-41.8	110.2	-42.6	100.5	-73.2
50	90.0	-3.7	94.2	-11.8	66.5	-48.5
80	103.0	12.8	85.0	-1.3	56.0	-37.1
85	105.0	15.5	77.0	1.1	51.8	-33.0
90	108.9	19.3	73.3	6.4	49.0	-26.9
95	111.5	24.7	56.0	13.6	40.0	-13.1
99	120.6	42.0	30.0	25.7	25.0	16.0

*See Section 15.3.2 for detail on minus (-) values

Horizontal reach vertical height, no trunk movement (NTM)

- 95th percentile value of 1115mm / 111.5cm from (finished floor level) FFL
- 50th percentile value of 900mm / 90.0cm from FFL
- 5th percentile value of 500mm / 50.0cm from FFL

When looking at alignment with BS 8300-2:2018 the 50th percentile value of 900mm / 90.0cm FFL is the closest to the 750mm horizontal reference plane for both comfortable side reach.

Horizontal reach horizontal measure, no trunk movement (NTM)

- 95th percentile value of 247mm / 24.7cm measured from front edge of chair to hand
- 50th percentile value of -37mm / -3.7cm measured from hand to front edge of chair
- 5th percentile value of -418mm / -41.8cm measured from hand to front edge of chair

The 5th[th] percentile value of -418mm / -41.8cm is the measurement of note as the distance at which those with the most limited horizontal measurement can reach. Note as this is a minus number this means that this signifies a dimension where reach is not beyond the front edge of a wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

Angled plug reach vertical height, no trunk movement (NTM)

Note this measurement was reversed (see Section 15.3.2 for details).

- 95th percentile value of 560mm / 56.0cm from FFL
- 50th percentile value of 942mm / 94.2cm FFL
- 5th percentile value of 1102mm / 110.2cm FFL

The 50th percentile has a value of 942mm / 942cm. This is the measurement of note as it signifies the distance from the floor level in which 50% of the participants hand would be able to reach. This measurement has been chosen as the 5th percentile value of 1102mm / 110.2cm is closer to the upper range of plug recommendations as per BS 8300-2:2018 and ADM (Volumes 1 and 2) so was discounted as well as on the basis that those with limited movement and / or dexterity who fall in higher percentiles may find it easier to have to reach upwards to a higher level than having to bend down to meet what would be a lower 95th percentile measurement from FFL.

Angled plug reach horizontal height, no trunk movement (NTM)

- 95th percentile value of 136mm / 13.6cm measured from front edge of chair to hand
- 50th percentile value of -118mm / -11.8cm measured from hand to front edge of chair
- 5th percentile value of -426mm / -42.6cm measured from hand to front edge of chair

The 5th percentile value of -426mm / -42.6m is the measurement of note as the distance at which those with the most limited horizontal measurement can reach. Note as this is a

minus number this means that this signifies a dimension where reach is not beyond the front edge of a wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

Straight down reach vertical height, no trunk movement (NTM) – measured from the side

Note this is a measurement that was reversed as explained in Section 15.3.2.

- 5th percentile value of 1005mm / 100.5cm FFL
- 50th percentile value of 665mm / 66.5cm FFL
- 95th percentile value of 400mm / 40.0cm FFL

The 5th percentile value of 1005mm / 100.5cm is the measurement of note as this signifies the distance from FFL that the lowest 5% of participants could reach from FFL. This is on the basis that those with limited movement and / or dexterity in the trunk who fall in lower percentiles (and further than FFL in reach) may find it easier to have to reach upwards to a higher level than having to bend down to meet what would be a lower 95th percentile measurement from FFL.

Straight down reach horizontal height, no trunk movement (NTM) – measured from the side

- 95th percentile value of -131mm / -13.1cm measured from hand to front edge of chair
- 50th percentile value of -485mm/ -48.5cm measured from hand to front edge of chair
- 5th percentile value of -732mm / -73.2cm measured from hand to front edge of chair

The 5th percentile value of -732mm / -73.2cm is the measurement of note as this is distance at which those with the most limited horizontal measurement can reach. Note as all percentiles in this data set shown above are minus numbers meaning that those in the 5th, 50th and 95th percentile were not beyond the front edge of their wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

15.4.2 Trunk movement (TM)

The below details the findings for plug socket data with trunk movement.

Table 62. Trunk movement plug percentile data.

Percentile Raw	Horizontal reach (cm) With trunk movement (TM) Shoulder (Vertical height)	Horizontal reach (cm) With trunk movement (TM) Shoulder (Horizontal measure)	Angled plug reach (cm) With trunk movement (TM) Reach (Vertical height)	Angled plug reach (cm) With trunk movement (TM) Reach (Horizontal measure)	Straight down reach (side) (cm) With trunk movement (TM) (Vertical height)	Straight down reach (side) (cm) With trunk movement (TM) (Horizontal measure)
5	47.0	-26.1	119.2	-42.3	90.8	-69.1
50	86.0	17.8	86.0	-12.2	56.8	-42.9
80	102.0	41.8	74.0	-1.6	43.5	-28.8
85	103.0	45.2	69.8	0.8	39.0	-23.9
90	106.0	50.1	60.0	5.6	36.0	-17.7
95	110.0	56.8	35.0	13.3	20.0	5.0
99	119.3	81.4	4.4	30.8	0.0**	34.6

*See Section 15.3.2 for detail on minus numbers.

**Note where there is zero measurements for 99th percentile vertical measurements this would be FFL.

Horizontal reach vertical height, with trunk movement (TM)

- 95th percentile value of 1100mm /110.0cm from FFL
- 50th percentile value of 860mm / 86.0cm from FFL
- 5th percentile value of 470mm / 47.0cm from FFL

When looking at alignment with BS 8300-2:2018 the 50th percentile value of 860mm / 86.0cm FFL is the closest to the 750mm horizontal reference plane for both comfortable and extended front and side reach.

Horizontal reach horizontal measure, with trunk movement (TM)

- 95th percentile value of 568mm/ 56.8cm measured from front edge of chair to hand
- 50th percentile value of 178mm / 17.8cm measured from front edge of chair to hand
- 5th percentile value of -261mm / -26.1cm measured from hand to front edge of chair

The 5th percentile value of -261mm / -26.1cm is the measurement of note as the distance at which those with the most limited horizontal measurement can reach. Note as this is a minus number this means that this signifies a dimension where reach is not beyond the front edge of a wheelchair and the measurement is the dimension from the front edge of the chair back to the hand. Note that this measurement is closer to the front edge of the chair when compared to data in Horizontal reach horizontal measure, no trunk movement (NTM) it was noted that this may be due to some who had limited trunk and side movement when combined, which therefore meant they reached closer to the front and downwards causing the measurement to be closer to the front edge of the chair.

Angled plug reach vertical height, with trunk movement (TM)

Note this is a measurement that was reversed as explained in Section 15.3.2.

- 95th percentile value of 350mm / 35.0cm from FFL
- 50th percentile value of 860mm / 86.0cm
- 5th percentile value of 1192mm / 119.2cm from FFL

The 5th percentile value of 1192mm / 119.2cm from FFL is the measurement of note as it signifies the distance from the floor level in which 95% of the participants' hands would reach – using this measurement over the 95th percentile will mean that those with reduced trunk mobility or longer reach ranges can still reach and those with more movement will not have to reach down as far to reach a plug.

It is noted that the 50th percentile value of 860mm / 860cm is closest to the -24° lower range of 650mm and 750mm of the horizontal plane in BS 8300-2:2018 (see Figure 59). However, note that this measurement did follow the exact same methodology as the BS 8300-2:2018 study as this methodology is unknown.

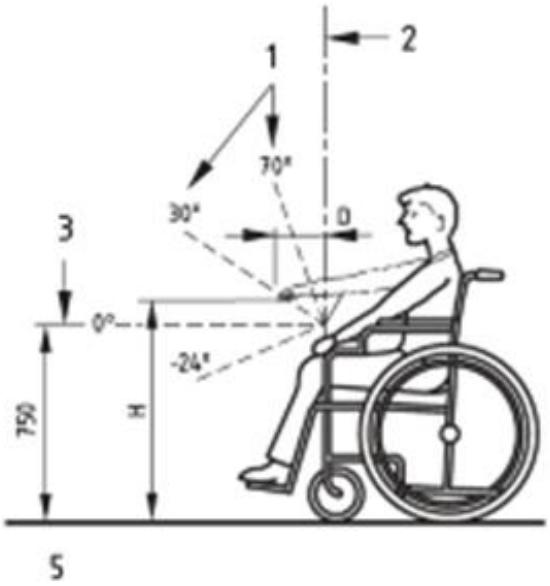


Figure 59. Snippet of figure E.3 from BS 8300-2:2018.

Angled plug reach horizontal measure, with trunk movement (TM)

- 95th value of 133mm / 13.3cm measured from front edge of chair to hand
- 50th percentile value of -122mm / -12.2cm measured from hand to front edge of chair
- 5th percentile value of -423mm / -42.3cm measured from hand to front edge of chair

The 5th percentile value of -423mm / -42.3cm is the measurement of note as the distance at which those with the most limited horizontal measurement can reach. Note as this is a minus number this means that this signifies a dimension where reach is not beyond the front edge of a wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

Straight down reach vertical height, with trunk movement (TM)- measured from the side

Note this is a measurement that was reversed as explained in Section 15.3.2.

- 5th percentile value of 908mm / 90.8cm
- 50th percentile value of 568mm / 56.8cm
- 95th percentile value of 200mm / 20.0cm

The 5th percentile value of 908mm / 90.8cm is the measurement of note as this signifies the distance from FFL that the lowest 5% of participants could reach from FFL. This is on the basis that those with limited movement and / or dexterity in the trunk who fall in lower percentiles (and further than FFL in reach) may find it easier to have to reach upwards to a higher level than having to bend down to meet what would be a lower 95th percentile measurement from FFL. Note that overall values for trunk movement are closer to FFL

than without trunk movement (0 Straight down reach vertical height, no trunk movement (NTM)) as would be expected.

Straight down reach horizontal height, with trunk movement (TM)- measured from the side

- 95th percentile value of 50mm / 5.0cm from front edge of chair to hand
- 50th percentile value of -429mm / -42.9cm measured from hand to front edge of
- 5th percentile value of -691mm / -69.1cm measured from hand to front edge of

The 5th percentile value of -691cm / -69.1cm this is the measurement of note as this is distance at which those with the most limited horizontal measurement can reach. Note as all percentiles in this data set shown above are minus numbers meaning that those in the 5th and 50th percentile where not beyond the front edge of their wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

15.5 General reach range findings

The following section provides a summary of the findings in relation to general reach ranges. All measurements were collected in centimetres (cm). The data presented in the tables has been rounded to the nearest 1 decimal place. See Section D.2 in Appendix D for the raw data tables.

The results have been split into those accommodating:

- Above arm reach.
- No trunk movement (NTM), which could be used for more generous ‘comfortable’ reach ranges.
- Trunk movement (TM) for the extended reach range, considered for activities that do not need to be performed on a regular basis.

15.5.1 Arm reach above head

Table 63. Reach range above head percentile data.

Percentile	Arm reach above head from finish floor height (FFL) (cm)
5	121.0
50	162.0
80	172.0
85	173.0
90	178.5
95	184.0
99	190.0

- 95th percentile value of 1840mm / 184.0cm
- 50th percentile value of 1620mm / 162.0cm
- 5th percentile value of 1210mm / 121.0cm

The 5th percentile value of 1210mm/121.0cm this is the measurement of note as this uses the lowest 5% of participants' arm reach is above the head. This loosely aligns with the upper range on 1200mm recommended in reach ranges as per ADM (450mm-1200mm). When comparing with BS 8300-2:2018, the extended front reach is 1150mm and comfortable at 1000mm.

15.5.2 No trunk movement (NTM)

Table 64. Lateral (side) arm reach percentile data (no trunk movement/ comfortable).

Percentile	Lateral (side) arm reach (vertical height) FFL (cm)	Lateral (side) arm reach (reach horizontal) (cm)
5	71.0	29.8
50	101.5	52.5
80	110.0	61.0
85	111.0	63.0
90	114.0	64.0
95	118.0	70.0
99	121.8	90.3

Lateral (side) arms reach vertical (arm extended out), no trunk movement (NTM)

- 95th percentile value of 1180mm / 118.0cm from FFL
- 50th percentile value of 1015mm / 101.5cm from FFL
- 5th percentile value of 710mm / 71.0cm from FFL

The 95th percentile value of 1180mm / 118.0cm is the measurement of note as it signifies the distance from the floor level in which 95% of the participants' hands would be able to reach when not engaging / stretching from the trunk. This aligns with the upper range on 1200mm recommended in reach ranges as contained in the current ADM Volume 1 (450mm-1200mm). This measurement has been chosen on the basis that those with limited movement and / or dexterity who fall in lower percentiles may find it easier to have to reach upwards to a higher level than having to bend down to meet what would be a lower 5th percentile measurement from FFL. The 5th percentile value of 710mm / 71.0cm has been used as the reference for horizontal plane measurement when looking at comparison to BS 8300-2:2018.

Lateral (side) arm reach horizontal (arm extended out), no trunk movement (NTM)

- 95th percentile value of 700mm / 70.0mm from edge of chair to hand
- 50th percentile value of 525mm / 52.5cm from edge of chair to hand
- 5th percentile value of 298mm / 29.8cm from edge of the chair to hand

The 5th percentile value of 298mm / 29.8cm is the measurement of note as it signifies the distance in which the lowest 5% of the participants' hands would be away from the edge of their wheelchair.

15.5.3 With trunk movement (TM)

Table 65. Lateral arm reach range percentile data (trunk movement / extended ranges).

Percentile	Lateral arm reach (vertical height) + trunk movement (cm)	Lateral arm reach (reach horizontal) + trunk movement (cm)
5	70.1	40.7
50	94.0	69.0
80	103.0	80.0
85	104.9	81.0
90	109.0	85.0
95	112.3	90.0
99	121.0	94.3

Lateral (side) arm reach vertical (arm extended out), trunk movement (TM)

- 95th percentile value of 1123mm / 112.3cm from FFL
- 50th percentile value of 940mm / 94.0cm from FFL
- 5th percentile value of 701mm / 70.1cm from FFL

The 95th percentile value of 1123mm / 112.3cm is the measurement of note as it signifies the distance from the floor level in which 95% of the participants' hands would be able to reach when not engaging / stretching from the trunk. This broadly aligns with the upper range of 1200mm recommended in reach ranges as per ADM Volume 1 (450mm-1200mm) and upper side (1170mm) and front (1150mm) extended reach ranges as detailed in BS 8300-2:2018. This measurement has been chosen on the basis that those with limited movement and / or dexterity who may fall in lower percentiles may find it easier to have to reach upwards to a higher level than having to bend down to meet what would be a lower 5th percentile measurement from FFL. In this case the 95th percentile should be used as the upper range and the 5th as the lower range providing a range dimension of 701mm / 70.1cm – 1123mm / 112.3cm

Lateral (side) arm reach horizontal (arm extended out), trunk movement (TM)

- 95th percentile value of 900mm / 90.0cm
- 50th percentile value of 690mm / 69.0cm
- 5th percentile value of 407mm / 40.7cm

The 5th percentile value of 407mm / 40.7cm is the measurement of note as it signifies the distance in which the lowest 5% of the participants' hands would be away from the edge of their wheelchair.

15.5.4 Picking up and posting letters

For posting letters the mounting height of boxes should be positioned as close to the horizontal plane references used for forward reach. This means that users will require little trunk movement and can post letters at a more comfortable positioning. Note that European standards (see footnote 49) currently recommend 700mm – 1700mm FFL the evidence behind this figure is unknown but it is likely that this focuses on standing user data hence being a greater distance from FFL than recommended in this report.

From the data collected for the horizontal plane:

- 95th percentile value of 1115mm / 111.5cm from (finished floor level) FFL
- 50th percentile value of 900mm / 90.0cm from FFL
- 5th percentile value of 500mm / 50.0cm from FFL

This provides a mounting height of 500mm – 1115mm / 50.0cm -111.5cm when considering the 5th and 95th percentile values. However, it is suggested future testing is done to supplement this data specifically for ambulant disabled participants which was not within the scope of this report.

For picking up letters, it is currently recommended in ADM (Volume 1, M4(3)) that there is clearance between the entrance door (hinge side) and adjacent walls and structures of 150mm, this is to allow for letter cages to be fitted, and the door to be opened, and post accessed without the need to bend / reach down to the floor. When considering the depth of letter cages from doors (i.e. to allow someone to comfortably reach the contents of the letter cages), the horizontal measurements from this research has been used.

- 95th percentile value of 247mm / 24.7cm measured from front edge of chair to hand
- 50th percentile value of -37mm / -3.7cm measured from hand to front edge of chair
- 5th percentile value of -418mm / -41.8cm measured from hand to front edge of chair

Note as this is a minus number this means that this signifies a dimension where reach is not beyond the front edge of a wheelchair and the measurement is the dimension from the front edge of the chair back to the hand.

This provides a depth range of -418mm – 247mm / -41.8cm – 24.7cm when looking at the 5th and 95th percentile values.

Figure 60. Horizontal reach horizontal measure, no trunk movement (NTM).

There should also be adequate landing space to access the door (see Section 16.4.1 for details on space requirements).

15.6 Reach ranges key findings

15.6.1 Reach ranges +70 & -24 for BS 8300-2:2018 comparison

Table 66 details the reach ranges for the 5th, 50th and 95th percentiles based on calculations using the measurements from this research study.

It is also noted that extended arm reach above the head from FFL (participants stretching from the trunk and shoulder upwards) was not included in the research conducted as it was not deemed that there would be a significant difference in this when compared to extended arm with no extension.

Arm reach above head

- Horizontal reach vertical height, no trunk movement (NTM)
- Horizontal reach vertical height, with trunk movement (TM)
- Lateral (side) arms reach vertical (arm extended out), no trunk movement (NTM)
- Lateral (side) arm reach vertical (arm extended out), trunk movement (TM)

Table 66. + 70- & -24-Degree measurements per percentile.

		5th	50th	95th
Front (Height)	+70° reach Comfortable	1167mm	1853mm	2223mm
	+70° reach Extended	1137mm	1813mm	2208mm
Front (Depth)	+70° reach Comfortable	-885mm	-705mm	-530mm
	+70° reach Extended	-728mm	-490mm	-208mm
Front (Horizontal plane comfortable)	Horizontal plane Horizontal reach vertical height, no trunk movement (NTM)	500mm	900mm	1115mm
Front (horizontal plane extended)	Horizontal plane Horizontal reach vertical height, with trunk movement (TM)	470mm	860mm	1100mm
Front (Height)	-24° reach Comfortable	212mm	488mm	635mm
	-24° reach Extended	182mm	448mm	621mm
Front (Depth)	-24° reach Comfortable	-480	-125mm	144mm
	-24° reach Extended	-323mm	90mm	460mm
Side (Height)	+70° reach Comfortable	1370mm	1968mm	2288mm
	+70° reach Extended	1359mm	1823mm	2177mm
Side (Depth)	+70° reach Comfortable	102mm	180mm	239mm
	+70° reach Extended	139mm	236mm	308mm
Side (Horizontal plane comfortable)	Horizontal plane Lateral (side) arms reach vertical (arm	710mm	1015mm	1180mm

		5th	50th	95th
	extended out), no trunk movement (NTM)			
Side (Horizontal plane extended)	Horizontal plane Section Lateral (side) arm reach vertical (arm extended out), trunk movement (TM)	701mm	940mm	1123mm
Side (Height)	-24° reach Comfortable	422mm	603mm	701mm
	-24° reach Extended	416mm	558mm	667mm
Side (depth)	-24° reach Comfortable	272mm	479mm	639mm
	-24° reach Extended	372mm	630mm	820mm

Note that for the data collected the distances between the arm and FFL for forward reach and side reach with no trunk movement were greater than that of the forward and side reach data with trunk movement for extended ranges this is due to the engagement of the trunk and so reaching both forward and laterally may cause the shoulder to drop causing a lesser distance between the arm and FFL. This has resulted in the extended reach ranges being reported as less than comfortable.

Note in the table for the – 24 depths for both front and side both the 95th and 5th percentiles have been highlighted this is as to give a good range the -24 number should take the 95th percentile and +70 the 5th however in the case of depth it should be considered the impact of using the 5th in the -24 as this may be more inclusive of allow those who cannot reach far past their front edge of their chair / side of wheel. This should be explored in the validation of the minus 24 and plus 70 dimensions. In

Table 67 to align with the other values to 95th has been used for the -24 measure.

Considering the data in Table 66 the comfortable forward reach ranges dimensions form the data is between

Front reach:

- 212mm – 1167mm for 5th percentile
- 488mm – 1853mm for 50th percentile
- 635mm – 2223mm for the 95th percentile

For extended forward reach ranges:

- 182mm – 1137mm for 5th percentile
- 448mm – 1813mm for 50th percentile
- 621mm – 2208mm for the 95th percentile

For comfortable depth:

- -885mm – -480mm for 5th percentile
- -705mm – -125mm for 50th percentile
- -530mm – 144mm for the 95th percentile

For extended depth:

- -728mm – -323mm for 5th percentile
- -490mm – 90mm for 50th percentile
- -208mm – 460mm for the 95th percentile

For comfortable side reach ranges:

- 422mm – 1370mm for 5th percentile
- 603mm – 1968mm for 50th percentile
- 701mm – 2288mm for the 95th percentile

For extended side reach ranges:

- 416mm – 1359mm for 5th percentile
- 558mm – 1823mm for 50th percentile
- 667mm – 2177mm for the 95th percentile

For comfortable depth:

- 272mm – 102mm for 5th percentile
- 479mm – 180mm for 50th percentile

- 639mm – 239mm for the 95th percentile

For extended depth:

- 372mm – 139mm for 5th percentile
- 630mm – 236mm for 50th percentile
- 820mm – 308mm for the 95th percentile

Table 67 compares data from this report with BS 8300-2:2018 data using the 5th and 95th percentile values for the side reach data as per Table 66. Note that the horizontal plane for each measurement as per Table 66 for both the 5th and 50th percentile have been reported in Table 67.

Table 67. Report data & BS 8300-2 data comparison.

	Access	Reach angle	Height		Depth	
			Comfortable (mm)	Extended (mm)	Comfortable (mm)	Extended (mm)
Wheelchair user	Front (BS 8300-2)	+ 70° Horizontal -24°	1000 (750) 650	1150 (750) 650	90 180 120	120 230 200
	Front (Report data)	+ 70° Horizontal -24°	1167 500 (5th percentile) 900 (50th percentile) 212	1137 470 (5th percentile 860 (50th percentile) 621	-885 -418 (5th percentile) -37 (50th percentile) 144	-728 -261 (5th percentile) 178 (50th percentile) 466
	Side (BS 8300-2)	+ 70° Horizontal -24°	1060 (710) 665	1170 (710) 630	100 220 165	135 310 230
	Side (Report data)	+ 70° Horizontal -24°	1370 710 (5th percentile 1015 (50th percentile) 701	1359 701 (5th percentile) 940 (50th percentile) 667	102 298 (5th percentile) 525 (50th percentile) 239	139 407 (5th percentile) 690 (50th percentile) 308

When comparing this data to BS 8300-2:2018, when looking at the 95th percentile for lower reach and 5th percentile for upper side reach, the data found in this report finds:

- Comfortable reach:
  - **Forwards:**
    - Data from this study: 212mm - 1167mm
    - BS 8300-2:2018 data: 650mm – 1000mm
  - **Side:**
    - Data from this study: 701mm-1370mm
    - BS 8300-2:2018 data: 665mm-1060mm
  - **Front depth:**
    - Data from this study: -888mm – 144mm
    - BBS 8300-2:2018: 90mm – 120mm
  - **Side depth:**
    - Data from this study: -728mm – 466mm
    - BS 8300-2:2018: 90mm – 120mm

- Extended reach:
  - **Forwards:**
    - Data from this study: 621mm – 1137mm
    - BS 8300-2:2018 data: 650mm – 1150mm
  - **Side:**
    - Data from this study: 667mm – 1359mm
    - BS 8300-2:2018 data 630mm-1170mm
  - **Front depth:**
    - Data from this study: 102mm – 239mm
    - BBS 8300-2:2018: 100mm – 165mm
  - **Side depth**
    - Data from this study: 139mm – 308mm
    - BS 8300-2:2018: 90mm – 120mm

15.7 Summary and key findings

The aim of this quantitative research focus study was to collect experimental data on reach ranges for people in wheeled mobility aids, specifically looking at reach ranges for everyday activities such as posting and picking up letters and reaching switches and sockets to operate controls to understand how this compares to current guidance.

The key findings include:

- For front reach:
  - The -24 reach ranges for height are closer to finished floor level than currently suggested in guidance
  - That +70 reach measures are higher than currently suggested in guidance
- For side reach:
  - The -24 reach ranges for height are higher from FFL that suggested currently in guidance
  - The +70 reach measures like for the front are higher than currently suggested in guidance
- For depth:
  - The data for depth reach ranges suggests that many people cannot reach past the front edge of their wheelchair (as signified by the minus numbers in the table above as explained in Section 15.3.2)
  - For side reach data +70 measurements for both comfortable and extended align loosely with current recommendations in BS 8300-2:2018.
  - The -24 measures are larger than currently recommended in BS 8300-2:2108.

Additional future research to build upon the results from this study include:

- Data collection for extended arm reach above head has been collected as seen in 15.5.1. However, collecting additional data with the participants stretching upwards from the shoulder and trunk could be used to calculate more accurately extended reach range data.
- A study to validate the findings as per the minus 24 and plus 70 dimensions as found in this report using mock ups of ranges in a lab-based study. This would include validating the percentile recommendations.
- Focused studies including ambulant disabled on the use of letter boxes, in particular the lower reach ranges.
- Reach range data to inform use of specific facilities such as petrol pumps and electric charging points.
- Reach ranges for ambulant disabled people focusing on heights and in particular the lower end of the reach range.

- Reach ranges when using counter tops and desks.

16. Research Stream 11: Doors and windows

This quantitative research focus study aimed to collect data on opening forces, motor skills, strength and space required to open and use doors, windows and operate buttons and to understand how this compares to current guidance.

To achieve this experimental data on the space required to reach and operate door and window handles, and the strength required to operate controls was collected.

16.1 Interpreting the data

Approach to doors

Data for approach to doors has been reported both overall (all participants) and by left- and right- handed use. In some cases, percentile data was not obtained due to the data set not being large enough.

This was the case for the following:

- All participants (see Table 72).
  - The 99th percentile was not obtained (This was due to the spread of data in the data set not being large enough to calculate the 99th percentile). Instead, the 99th percentile uses the 100th percentile data.
- Left- and right-hand use (see Table 73):
  - For left-hand use, the 5th 95th and 99th was not obtained due to the data set being smaller than the overall data set. Instead:
    - The 5th percentile uses the 6th percentile data.
    - The 95th percentile uses the 94th percentile data.
    - The 99th percentile uses the 100th percentile data.
  - For right-hand use, the 99th percentile was not obtained (This was due to the spread of data in the data set not being large enough to calculate the 99th percentile). Instead, the 99th percentile uses the 100th percentile data.

Where an alternative percentile value has been used, this is marked with an asterisk in the data table.

Door forces

One participant was discounted from the door forces data as they had no reach ability to complete the force tasks.

Percentile data for the 99th percentile was not obtained due to the spread of data. Instead, the 99th percentile uses the 98th percentile data. However, for force data the 5th percentile is the measurement of note; therefore, the use of 98th percentile data does not affect the recommendations made in this report.

For downwards force data, there is no comparative measure within current guidance (BS 8300-2:2018 has detail on force required for turning keys and to lift handles but not pushing them down). Therefore, downwards force data obtained in this study has been compared to the following guidance from BS 8300-2:2018.

The torque force to operate keys and cylinder runs should not exceed 0.5Newtons (N).

- The torque force required to operate a lever handle for a window should not exceed 8N.m (Newton meter) to depress and 5.5N to lift a handle with an oval cross section 4N to both depress and lift a handle with a rectangular cross section. (Torque force is the force in Newton exerted over a distance of 1 metre).

16.2 Current design guidance on doors and windows

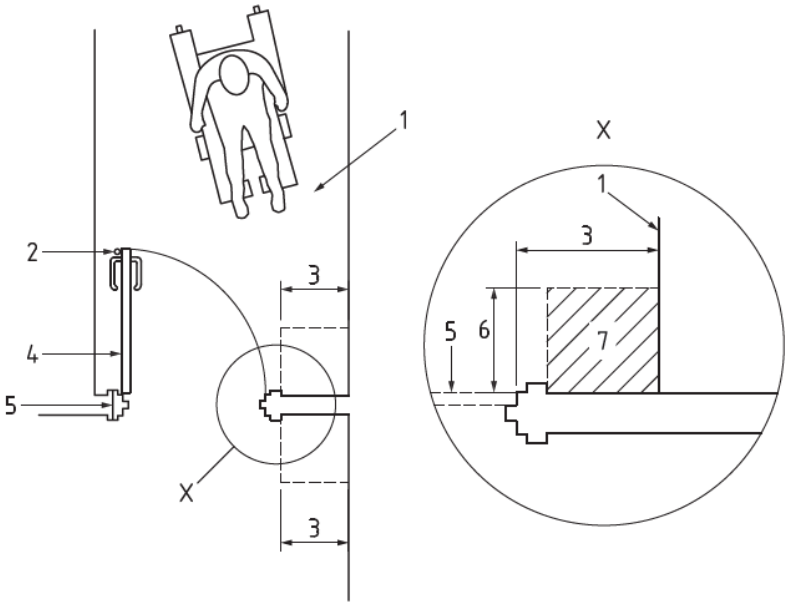
Current guidance documents BS 8300-2:2018 and Approved Document M (ADM) (Volume 1 and 2) provide some recommendations on door access and door forces.

BS 8300-2:2018

Access to doors

- There should be at least 300mm unobstructed space (nib) provided between the leading edge of a door and return wall or other obstruction (see Figure 61).
- BS 8300-2:2018 recommends increasing this space to 600mm may improve the manoeuvrability of doors reducing the risk of wheelchairs colliding with the wall and enabling users to pass through doors more easily.
- Approach to doors should have an approach width of at least 1800mm.

Figure 3 — *Example of door location and side clearance on the pull side*



Key

1	Return wall, partition or other obstruction
2	Door stop where appropriate
3	Minimum 300 mm clear space between the line of the leading edge of the door (when closed) and the return wall (may be reduced if door is opened by remote automatic control)
4	Door hung from corner of room
5	Opening face of door
6	Maximum 200 mm
7	Zone within which a door reveal, column or other obstruction may be situated

Figure 61. Door location and side clearance on pull side BS:8300-2:2018 ©

Door and window opening

- Opening force for doors from the leading edge should not be more than 30N from 0° (door closed) to 30° open. From 30° to 60° the force to open should be no more than 22.5N.
- Door fittings should be easily reached recommended mounting height 800mm – 1050mm FFL (900mm preferred).
- It should be possible to operate all door furniture with one hand without needing to grasp or twist (lever doors preferred).
- The hand grip zone should be at least 95mm for lever handles; there should be 45mm depth of the hand grip zone from the face of the door and lever diameters should be at least 19mm.
- The torque force to operate keys and cylinder runs should not exceed 0.5N.
- The torque force required to operate a lever handle for a window should not exceed 8N.m to depress and 5.5N to lift a handle with an oval cross section 4N to both depress and lift a handle with a rectangular cross section.

- Torque force is the force in Newton exerted over a distance of 1m (note this has been abbreviated as N.m unit)

Approved Document M (Volume 1: Dwellings)

Section 3.14 diagram 3.2 of ADM Volume 1 details the main measurements of clear opening widths and other features of external and internal doors. These are summarised below:

Access to doors and windows

- 1500mm x 1500mm turning circle should be provided inside entrance areas when the door is closed.
- 300mm nib should be provided on the leading edge of the door, maintained for a distance of at least 1800mm beyond it. 200mm nib on the following edge of door should be provided and maintained for a distance of at least 1800mm beyond it (see below for differences for private entrances).
- Doors within lobbies should be at least 1500mm apart and have 1500mm between door swings.

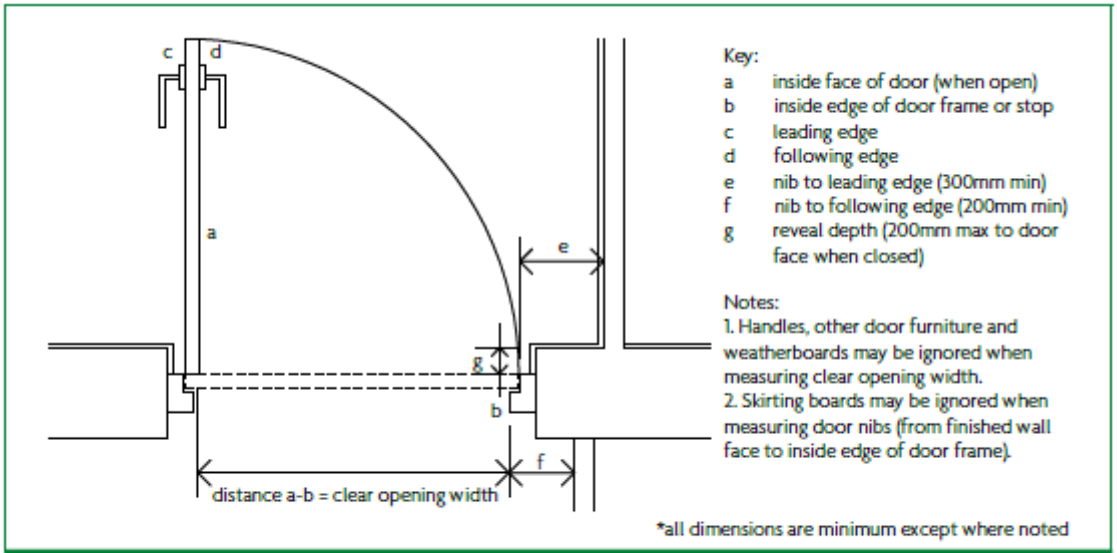


Figure 62. Measurements of clear opening width and other features of external and internal doors ADM Volume 1.

Door and window forces

- Door forces should be no more than 30N from 0° to 30° and 22.5N from 30° to 60° of the opening cycle (0° being the door in its closed position).

Within Approved Document M (Volume 2: Buildings other than dwellings)

Access to doors and windows

- 300mm minimum unobstructed space should be provided on the pull side of the door.
- There is a level landing of at least 1500mm x 1500mm clear of any door swings in front of entrances.

Table 2 Minimum effective clear widths of doors

Direction and width of approach	New buildings (mm)	Existing buildings (mm)
Straight-on (without a turn or oblique approach)	800	750
At right angles to an access route at least 1500mm wide	800	750
At right angles to an access route at least 1200mm wide	825	775
External doors to buildings used by the general public	1000	775

Note:

The effective clear width is the width of the opening measured at right angles to the wall in which the door is situated from the outside of the door stop on the door closing side to any obstruction on the hinge side, whether this be projecting door opening furniture, a weather board, the door or the door stop (see Diagram 9). For specific guidance on the effective clear widths of doors in sports accommodation, refer to ''accessible sports facilities'.

Diagram 9 Effective clear width of doors

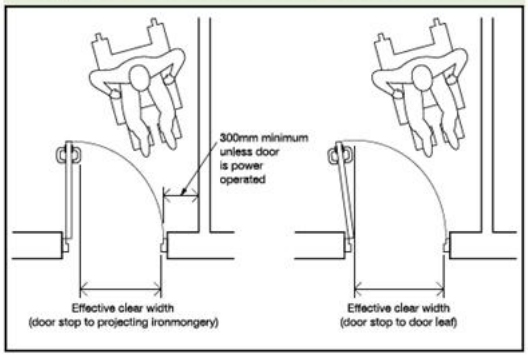


Figure 63. Minimum effective clear width of doors ADM Volume 2.

Door and window opening

- Door forces should be no more than 30N from 0° to 30° and 22.5N from 30° to 60° of the opening cycle (0° being the door in its closed position).
- Door opening furniture should be operated with one hand using a closed fist e.g., a lever handle.

16.3 Methodology

The original scope was for a laboratory-based study at LU. However, participant willingness to attend the laboratory-setting was impacted by the COVID-19 pandemic. Therefore, the LU team adapted the collection equipment to collect data at selected public locations (i.e. where a range of people would be available and invited to participate).

It has not been possible to make clear conclusions on the use of doors and forces by ambulant disabled people, as the sample size of ambulant disabled people was too small[49]. Therefore, data from ambulant disabled people and wheeled mobility aid users was combined during analysis.

16.3.1 Handle access

The study used a mix of photogrammetric and manual measurements with a measuring tape by researchers following a standardise method (see Table 68).

- Participants were allowed to select their approach towards the mock-up door (containing the force measuring equipment / handle). The handle was fixed at 1000mm from the floor and the user selected their preferred hand for the opening; the hand selected was recorded.
- The furthest approach width that a participant used to approach and use the handle, for both the right- and left-hand approaches to the handle was measured.
- The right- and left-hand approach widths were combined (calculated by adding the left- and right-hand measurements together) to give the overall approach width. The intention being that this measurement indicated the widest width required by participants on the approach to a door or window.

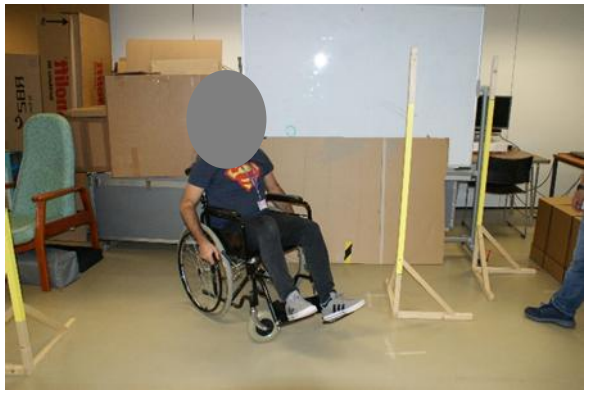
16.3.2 Door forces

A range of force data was collected using an electrical strain gauge which reported data in Newtons (N).

- A mock door stand was put up at the visited sites
- The following measures were taken in two positions - anterior (forwards) and lateral (side) (see Table 69)
- Pushing anterior (forwards)
- Pulling anterior (forwards)
- Downward force anterior (forwards)
- Pushing lateral (side)
- Pulling lateral (side)
- Downward force lateral (side)

[49] A study with a larger sample size of ambulant disabled people has been identified as a consideration for future research.

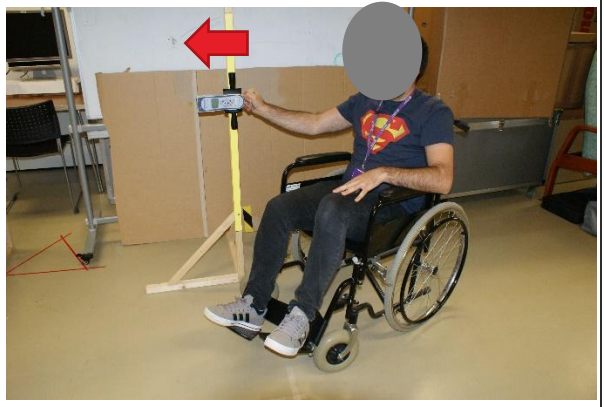
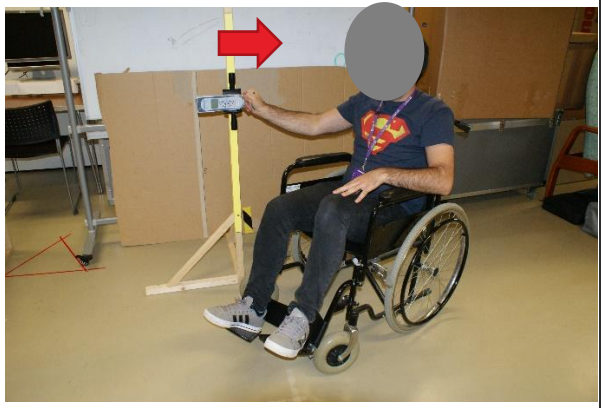
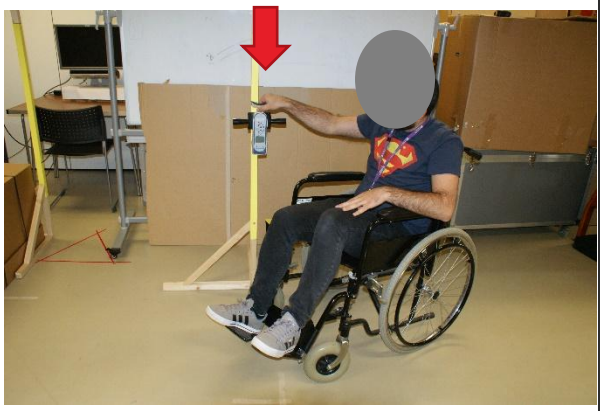
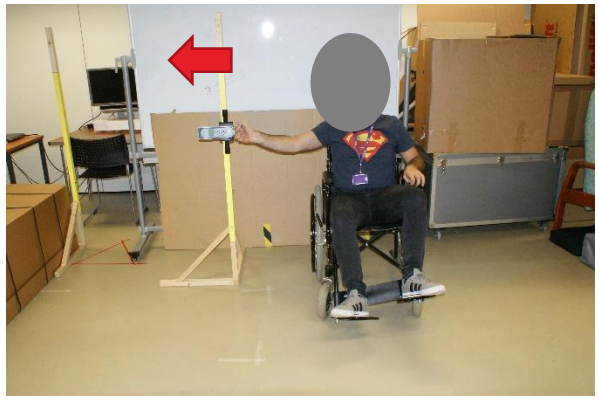
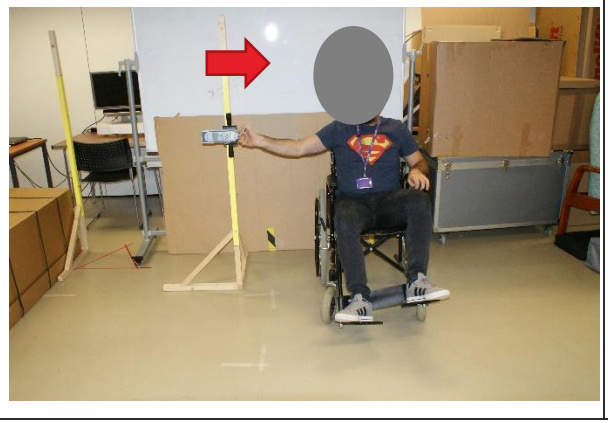
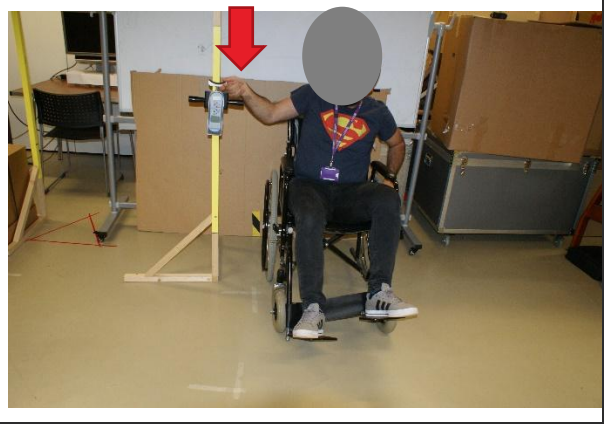
Table 68. User approaching and leaving door space / measuring door handle position[50].

Approaching	Accessing door handle	Leaving
		

Measuring left door handle position	Measuring right door handle position
	

[50] Note these photographs are for illustrative purposes for positioning and the door handle used in data collection is not shown.

Table 69. Push, pull, downward force – anterior and lateral positions.

Pushing Anterior	Pulling Anterior	Down Force Anterior
		
Pushing Lateral	**Pulling Lateral**	**Down Force Lateral**
		

16.3.3 Sample

The data that has been collected as part of this study was part of a small-scale ergonomic research study with the intention to provide comparisons to the current recommendations included in BS 8300-2:2018.

Full details of the number of participants per aspect of this study (approach / accessing doors, and door forces) are detailed in Table 70. A total of 63 people took part in this study across 5 sites.

Table 70. Participant numbers.

	Accessing doors and windows	Door / window forces
Wheelchair user participants	61	61
Ambulant disabled participants[51]	2	2
Total participants	63	63
Total for study	63	

16.4 Findings

This section details the findings from this ergonomic study. This has been split into the following sections:

- Approaches to doors and windows (see Section 16.4.1).
- Door and window forces (see Section 16.4.2).

Percentiles ranging from the 5th through to the 99th have been shown in the tables below to see the extent of data collected. The 5th, 50th and 95th percentile dimensions have been included for each measurement, with the 5th covering the lowest 5th percentile of the data set, the 50th the lowest 50th percentile and the 95th excluding the top 5th percentile of the data set. Note where alternative percentiles have been used (as explained in Section 16.1) these have an asterisk next to the data in the tables below.

The hand used to complete the tasks was noted by the LU research team. There were 46 right-handed and 17 left-handed participants (73% and 27% respectively) (see Table 71).

Typical estimates suggest 10% of the population are left-handed[52].

[51] Due to small sample size of ambulant disabled people, data from all participants was combined during analysis.

[52] Scharoun, S.M. and Bryden, P.J., 2014. Hand preference, performance abilities, and hand selection in children. *Frontiers in Psychology*, *5*, p.82.

Table 71. Handedness of participants.

	Right	Left
Participants	46	17

16.4.1 Approaches to doors and windows

For door and window approach, the following data was collected:

- Overall door / window approach width.
- Door approach to the left of the door handle.
- Door access to the left split into left- or right-hand use.
- Door approach to the right of the door handle.
- Door access to the right split into left- or right-hand use.

BS 8300-2:2018 recommends a general circulation width of 1800mm (see Section 16.2) (note specifically in relation to doors and windows but for all circulation spaces) and ADM (Volume 1 and 2) suggest a turning space of 1500mm x 1500mm or 1500mm turning circle.

In the below the measure that is closest to current guidance has been highlighted. Note, the key percentile is the 95th percentile value as this includes 95% of participants (excluding 5% of participants with the largest approach widths). See Section D.3 in Appendix D for data tables to 2 decimal places.

Table 72. Results for all participants (both right and left-handed).

Percentile	Door approach to right (cm)	Door approach to left (cm)	Total door approach (cm)
5th	84.1	87.3	181.2
50th	120.0	127.0	239.0
80th	141.6	141.8	274.2
85th	145.4	149.7	287.7
90th	157.6	152.6	295.4
95th	188.6	165.9	344.8
99th	207.0*	280.0*	487.0*

(*) alternative percentiles have been used (as explained in Section 16.1).

Table 73 shows the percentile data for door access split by which hand was used.

Table 73. Results for participants split by handedness.

Percentile	Door approach to right (Right-hand) (cm)	Door approach to left (Right-hand) (cm)	Total door approach (Right-hand) (cm)	Door approach to right (Left-hand) (cm)	Door approach to left (Left-hand) (cm)	Total door approach (Left-hand) (cm)
5th	84.3	86.3	160.7	80.6*	88.0*	171.2*
50th	112.5	120.5	230.0	133.0	131.0	254.0
80th	134.0	133.0	263.0	149.2	151.0	293.0
85th	144.0	136.5	272.6	164.8	152.8	311.3
90th	157.0	151.0	290.0	193.4	181.6	375.0
95th	171.8	165.8	319.9	205.6*	270.2*	475.8*
99th	196.0*	167.0*	363.0*	207.0*	280.0*	487.0*

(*) alternative percentiles have been used (as explained in Section 16.1).

16.4.1.1 Overall door and window approach

Note, for all data, the key percentile is the 95th percentile value as this includes 95% of participants.

Data for all participants (both right- and left-hand approach)

The below discusses the results from the data in relation to the overall approach width required. When looking at the furthest distance from the door:

- The 5th percentile reports 1812mm / 181.2cm.
- The 50th percentile reports 2390mm / 2390cm.
- The 95th percentile reports 3448mm / 344.8cm.

When looking at the data in comparison to current guidance the data in the report suggests that the 5th percentile of 1812mm / 181.2cm is the closest to the 1800mm circulation width as recommended in BS 8300-2:2018 as well as the 1500mm x 1500mm turning space or 1500mm turning circle or landing space in front of doors currently recommended by ADM (Volumes 1 and 2).

Data for right-hand used on approach

- The 5th percentile reports 1607 / 160.7cm.
- The 50th percentile reports 2300mm / 230.0cm.
- The 95th percentile reports 3199mm / 319.9cm.

The 5th percentile measurement of 1437mm / 143.7cm is the closest (of all the percentile values) to the 1500mm x 1500mm turning space or 1500mm turning circle or landing space currently recommended in ADM (Volumes 1 and 2) as with the data for all participants. As well as the 1800mm circulation width as recommended in BS 8300-2:2018.

Data for left-hand used on approach

The overall approach width required by all percentiles for left-hand used on approach were larger than the right-hand approach.

- The 5th percentile reports 1712mm / 171.2cm.
- The 50th percentile reports 2540mm / 254.0cm.
- The 95th percentile reports 4758mm / 475.8cm.

The 5th percentile measurement of 1578mm / 157.8cm aligns the closest with the 1500mm x 1500mm turning space or 1500mm turning circle or landing space currently recommended in ADM (Volumes 1 and 2). This measurement is closest to the 1800mm currently recommended as circulation width in BS 8300 Parts 1 and 2.

Summary

Data for the 95th percentile suggests that more space may be required than currently suggested for general approach widths in BS 8300-2 and ADM (Volumes 1 and 2).

When looking at overall approach for all participants (both right and left hand), right hand and left hand the 5th percentile values where closest to recommendations for general circulation width as per BS 8300-2:2018 and for the landing and turning circle spaces as per ADM Volumes 1 and 2.

Left-hand use required a larger overall approach width than right-hand use.

16.4.1.2 Space required to the left of the door handle

Note, for all data, the key percentile is the 95th percentile value as this includes 95% of participants.

Data for all participants (both right- and left-hand approach)

- For the 5th percentile, this was 873m / 87.3cm.
- For the 50th percentile, this was 1270mm / 127.0cm.
- For the 95th percentile, this was 1659mm / 165.9cm.

Data for right-hand used on approach

- For the 5th percentile, this was 863mm / 86.3cm.
- For the 50th percentile 1205mm / 120.5cm.
- For the 95th percentile, this was 1658mm / 165.8cm.

Data for left-hand used on approach

The data set for the 5th percentile left-hand used on approach is lower than that of right-hand used on approach, however both the 5th percentile and 95th are larger for the left-hand used approach.

- For the 5th percentile, this is 880mm / 88.0cm.
- For the 50th percentile, this is 1310mm / 131.0cm.
- For the 95th percentile, this is 2702mm / 206.7cm.

Summary

The findings show that participants approaching from the left using their left hand required a larger approach width to the left than those approaching with the right hand.

16.4.1.3 Space required to the right of the door handle

This has been shown as the full data set and further split into hand used.

Note, for all data, the key percentile is the 95th percentile value as this includes 95% of participants.

Data for all participants (both right- and left-hand approach)

- For the 5th percentile, this is 841mm / 84.1cm.
- For the 50th percentile, this is 1200mm / 120.0cm.
- For the 95th percentile, this is 1886mm / 188.6cm.

Data for right-hand used on approach

- For the 5th percentile, this is 843mm / 84.3cm.
- For the 50th percentile, this is 1125mm / 112.5cm.
- For the 95th percentile, this is 1718mm / 171.8cm.

Data for left-hand used on approach

The overall data set for left-hand used on approach is larger than right-hand used on approach.

- For the 5th percentile, this is 806mm / 80.6cm.
- For the 50th percentile, this is 1330mm / 133.0cm.
- For the 95th percentile, this is 2056mm / 205.6cm.

Summary

The findings show that participants approaching from the right using their left hand required a larger approach width to the left than those approaching with the right hand.

16.4.1.4 Use and approach of handles

The following section details a combination of measurements from the wider Part M research undertaken to give a more detailed view on the use and approach to doors and windows to supplement the data that has been collected in this report. See Section D.4 in Appendix D for data tables from the Objective 1 and 2 report.

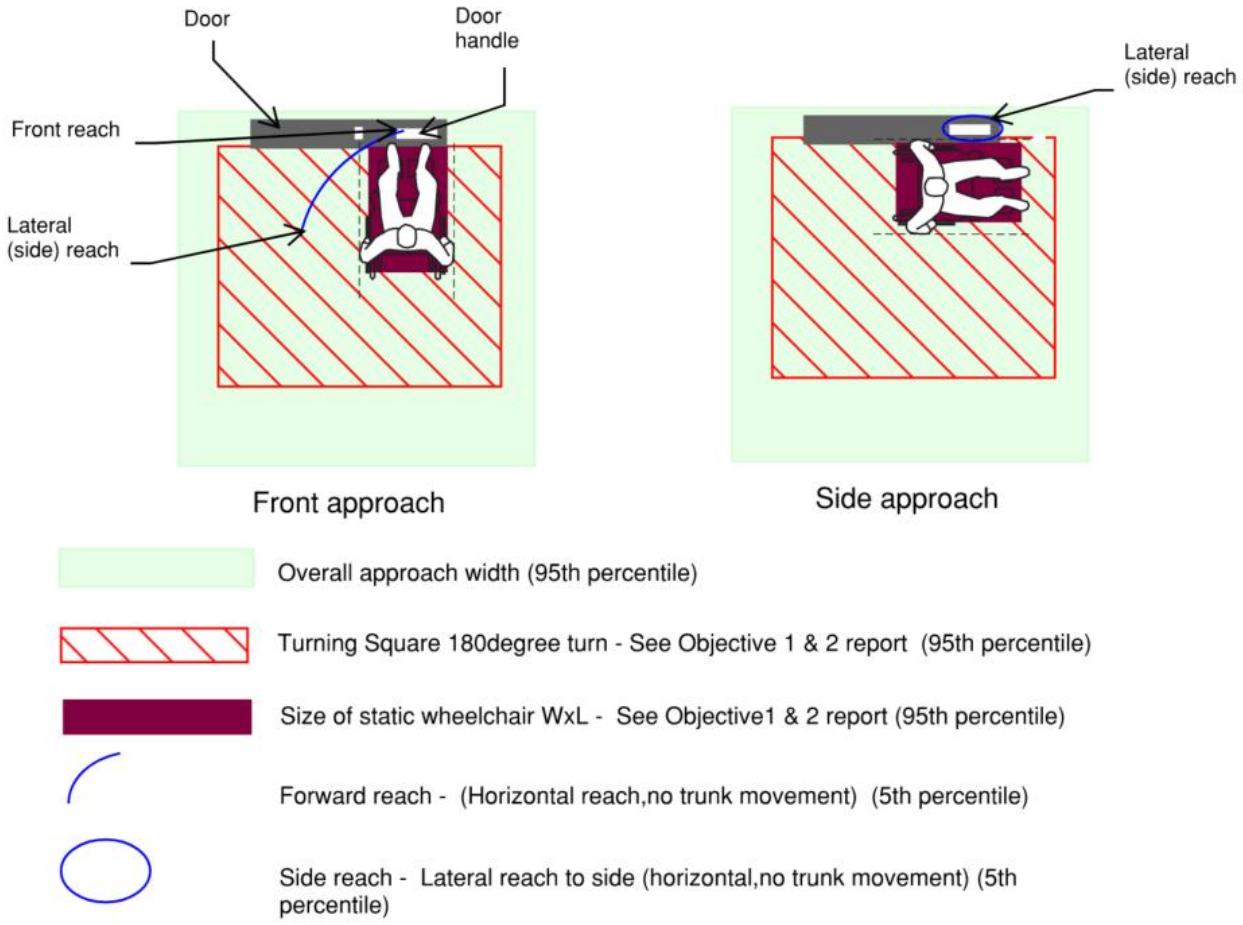


Figure 64. Use and approach of handles (doors and windows)

Front approach

- Overall approach width (see Section 16.4.1.1): 3448mm / 344.8cm (95th percentile)
- Turning square: 2483mm W x 2487mm L (95th percentile)
- Static wheelchair: 850mm W x 1590mm L (95th percentile)
- Forward reach horizontal no trunk movement: -418mm / -41.8 (5th percentile)
  - In the case of this measurement, note as explained in Section 15.3.2 where minus numbers where returned - this represents represent those who could not reach beyond the front edge of their chair and the measurement is the dimension from the front edge of the chair back to the hand. Where positive numbers are shown this is the distance advancing away from the front edge of the chair to the knuckle of the hand.

- Lateral (side) reach Horizontal no trunk movement: 298mm / 29.8cm (5th percentile)

Side approach

- Overall approach width (see Section 16.4.1.1): 3181mm (95th percentile)
- Turning square: 2483mm W x 2487mm L (95th percentile)
- Static wheelchair: 850mm W x 1590mm L (95th percentile)
- Lateral (side) reach horizontal no trunk movement: 318mm (5th percentile)

16.4.2 Door and window forces

Table 74 details the findings from the force data collection.

The 5th percentile is the measure of note, where 95 percent of participants can operate the door or window. All measurements are shown to 1 decimal place and units are in Newtons (N). See Section D.5 in Appendix D for data to 2 decimal places.

All the percentiles, except the 5th percentile, report opening forces higher than the current recommendations of 30N maximum for opening a door from 0-30° and 22.5 N for door opening from 30° - 60 ° of the opening cycle (noting that 0° is a door when shut).

Table 74. Forces results.

Percentile	Push Force Anterior (N)	Pull Force Anterior (N)	Down Force Anterior (N)	Push Force Lateral (N)	Pull Force Lateral (N)	Down Force Lateral (N)
5th	16.7	25.3	18.7	16.8	29.8	36.0
50th	60.0	93.5	83.5	97.5	135.5	88.0
80th	112.2	146.2	120.6	144.0	193.0	154.0
85th	123.6	174.0	138.4	160.3	214.2	158.6
90th	136.8	189.8	151.8	191.3	242.1	183.6
95th	162.4	232.5	196.0	214.7	266.9	209.6

16.4.2.1 Anterior (forward) forces

When looking at anterior push force (this would be the measurement used to assess pushing a door or window from front-on):

- The 5th percentile value of 16.7N is lower than both the 30N for door opening from 0-30° or the 22.5N from door opening from 30°-60° suggesting that for push forces, current recommendations may be too high.

When looking at the pull force (this would be the measurement used to assess pulling a door or window from front-on):

- The 5th percentile value of 25.3N is lower than the 30N for door opening from 0° - 30° is higher than the 22.5 N for door opening from 30° - 60 ° suggesting that for pull forces, current recommendations for 0° - 30° opening may be too high.

When looking at the anterior downwards force (this would be the measurement used to operate a lever handle on a door or window from front-on):

- The 5th percentile value 18.7N is higher than the 0.5N to operate keys, the 8N to depress and 5.5N to lift a handle.
- This suggests that a suitable recommendation for the force required to push a handle down should be no more than 18.7N.

Summary

When looking at all force actions, the push force was the lowest across all percentiles.

The 5th percentile value for pull force was the highest across all 5th percentile data for anterior (forward) forces, meaning this is the force action which participants had the highest strength.

For the overall percentile data set from lowest to highest the results across all percentiles 5th through to 98th were push force, followed by down and pull, as the highest.

The 5th percentile value for down forces suggests that the force required to push a handle down should not exceed 18.7N for front forces.

16.4.2.2 Lateral (side) forces

When looking at anterior push force (this would be the measurement used to assess pushing a door or window from side-on):

- The 5th percentile value of 16.8N is lower than both the 30N for door opening from 0-30° or the 22.5 N for door opening from 30° - 60 °, suggesting that for pull forces, current recommendations may be too high.

When looking at the pull force (this would be the measurement used to assess pulling a door or window from side-on):

- The 5th percentile value of 29.8N is marginally lower than the 30N for door opening from 0° - 30° and higher than the 22.5 N for door opening from 30° - 60 °, suggesting that for pull forces, current recommendations may be suitable.

When looking at the anterior downwards force (this would be the measurements used to assess using a lever handle on a door or window from side-on):

- The 5th percentile value 36.0N is higher than the 0.5N to operate keys, the 8N to depress and 5.5N to lift a handle.

The 5th percentile value of 36.0N for down for the lateral (side) force is 36.0N. It is however noted that force requirement should not be made larger than is recommended in current guidance and in this instance the front approach value of 18.7N as detailed in Section 16.4.2.1 is deemed a more inclusive measure and should there for be used as a suggested maximum measure for the force required to push a handle down.

Summary

All of the 5th percentile lateral forces are higher than that of the front suggesting that participants were able to exert more force laterally than front-on.

When looking at all force actions the downward force was the highest across all 5th percentile values for lateral forces:

- The 5th percentile value for down force was the highest across all 5th percentile data for lateral (side) forces, meaning this is the force action which participants had the highest strength followed by pull and then push forces.
- The 5th percentile value of 36.0N for down for the lateral (side) force is 36.0N. It is however noted that in this instance the front approach value of 18.7N as detailed in Section 16.4.2.1 is deemed a more inclusive measure and should there for be used as a suggested maximum measure for the force required to push a handle down.

16.5 Key findings and summary

The aim of the study was to collect data on opening forces, motor skills, strength and space required to open and use doors, windows and operate buttons and to understand how this compares to current guidance.

The key findings are:

- Approach to doors and windows:
  - Based on the data, more space may be required for general approach widths to doors and windows than currently suggested in ADM Volume 1 and 2 and BS 8300-2:2018, with approximately the 5th percentile of participants accommodated by current guidance.
  - Those approaching and operating the door handle with their left hand had a larger approach width across all percentiles than participants approaching and operating with their right hand.
- Approaches to and use of door and window handle[53]:
  - Front approach:
    - Overall approach width (see Section 16.4.1.1): 3181mm (95th percentile).
    - Turning square: 2483mm W x 2487mm L (95th percentile from Objective 2b data collection, all wheeled mobility aid types, including scooters; see Section 13.2.2).
    - Static wheelchair: 850mm W x 1590mm L (95th percentile from Objective 2b data collection, all wheeled mobility aid types, including scooters; see Section 13.2.1).
    - Forward reach horizontal no trunk movement: -418mm / -41.8cm (5th percentile).
    - Lateral (side) reach Horizontal no trunk movement: 298mm / 29.8cm (5th percentile).

[53] As outlined in Section 16.4.1.4, these findings draw from data from the reach range section of this report (see Section 15) and data collected as part of Objectives 1 and 2.

- Side approach:
  - Overall approach width (see Section 16.4.1.1): 3181mm (95th percentile).
  - Turning square: 2483mm W x 2487mm L (95th percentile).
  - Static wheelchair: 850mm W x 1590mm L (95th percentile).
  - Lateral (side) reach horizontal no trunk movement: 298mm /29.8cm (5th percentile).

- Door and window - anterior (forward) forces
  - When looking at anterior (front) and lateral (side) approaches considering push, pull and downward motions on the door handle, the data collected for the 5th percentile showed that for all motions the forces were lower than the current recommended from ADM Volumes 1 and 2 and BS 830-2:2018 guidance of 30N maximum force for opening a door from 0-30° and 22.5N. The 5th percentile values for pull force for both anterior (front) and lateral (side) were larger than the 22.5N maximum for opening a door from 30° - 60 ° as per both ADM Volumes 1 and 2 and BS 8300-2:2018.
  - In detail:
    - The 5th percentile value for pull force was the highest across all 5th percentile data for anterior (forward) forces, meaning this is the force action which participants had the highest strength.
    - The 5th percentile value for down forces suggests that the force required to push a handle down should not exceed 18.7N for front forces.
    - When looking at all force actions the downward force was the highest across all 5th percentile values for lateral (side) forces.
    - All of the 5th percentile lateral (side) forces are higher than that of anterior (front) forces, suggesting that participants were able to exert more force laterally (side on) than anteriorly front-on.
    - The 5th percentile value of 36.0N for down for the lateral (side) force is 36.0N. It is however noted that force requirement should not be made larger than is recommended in current guidance and in this instance the front approach value of 18.7N as detailed in Section 16.4.2.1 is deemed a more inclusive measure and should there for be used as a suggested maximum measure for the force required to push a handle down.

Additional future research to build upon the results from this study include:

- Approaches to doors
  - Larger sample of ambulant disabled users (including those with and without assistive aids).
  - Further study to assess the depth of reveal that can be provided to allow access to handle (currently not specified in guidance except for ADM Volume 1 for M4(3) Category 3: Wheelchair user dwellings).

- Door forces
  - Larger sample of ambulant disabled users (including those with and without assistive aids).
  - Data set which detailed if wheelchair users were in manual or powered wheelchairs as well as additional questions to assess any co-occurrence of disabilities, to explore if there is any impact on operation of doors based on chair type.
  - Additional research into the use of handle types / profiles and suitability of current guidance on handle design.

17. Research Stream 12: Ramps and gradients

The focus study on ramps and gradients aimed to understand the tipping points of unoccupied and 'occupied' wheeled mobility aids on ramps and slopes and disabled people's experience of using ramps.

To achieve this the following studies were undertaken:

- The tipping gradient of unoccupied and 'occupied[54]' wheeled mobility aids (including both manual and powered wheelchairs) for both posterior (back) and lateral (side) tipping.
- A survey on disabled people's experience of using existing ramps in the built environment.

17.1 Tipping gradient study

For this report, the average and shallowest tipping gradients for wheeled mobility aids have been reported. Data has been rounded up or down to the nearest 1 decimal point for gradients. Data tables are provided in Section D.6 of Appendix D.

17.1.1 Data constraints

Due to ethical considerations for this study (i.e. health and safety of using real wheelchair users to establish a tipping point), the data collected used a weighted mannequin in a seated position in different types of wheelchairs, instead of a real person. This means that, though the additional weight of a person has been considered in the tipping study it is not a true representation of individuals' experiences as, the following factors could not be replicated:

- A person's centre of gravity
- If additional equipment, such as torso supports, are used or additional weight carried on chairs.
- Varying weight considering people with different body sizes and how weight distribution may differ for individuals such as lower limb amputees.
- Body movement or repositioning by an individual in their chair when they are not in a stationary position.
- The lateral forces involved in ascending or descending a ramp.
- Anterior (front) tipping data where the chair would be faced forwards and tipped – this would have been beneficial when looking at ramp descent. However, this posed a health and safety risk for researchers with the current methodology, and so would need to be considered as part of further future research.

[54] For safety reasons, weighted mannequins were used in place of users in the 'occupied' condition. See Section 17.3.1 for more information on the methodology.

The mannequins used were weighted at a single size which represents approximately a 50th percentile of female UK adults between 18 and 65 years for stature and weighted at 25kg. For health and safety reasons for the researchers, the mass of the weight placed in the seats was restricted. This has provided comparable results for each chair type tested, but it is noted that this does not simulate different weight distributions across different demographic groups.

17.2 Current design guidance on ramps and slopes

Both Approved Document M (ADM) Volumes 1 and 2 and BS 8300 Parts 1 and 2 define a ramp as a gradient between 1:12 and 1:20 and a gradient between 1:21 and 1:59 as a slope.

The following guidance is provided for the design of ramps and slopes in the built environment. Specific detail on tipping points is not included in either ADM Volume 1 and 2 nor BS 8300 Parts 1 and 2.

- No individual flight of ramp should have a going greater than 10m or a rise of more than 500mm.
- Ramp widths should not be less than 1500mm.
- Landings should be provided at the foot and head of a ramp – these should be at least the width of the ramp and not less than 1500mm long.
- Landings should be level. Where water is likely to pool, a crossfall of no more than 1:50 is acceptable to help with drainage.
- Handrails should be provided to both sides of a ramp.

Neither document provides specific detail on tipping points for ramps or slopes.

17.3 Methodology

Data collection took place in lab facilities at Loughborough University (LU) by the LU research team. For safety reasons, no participants were involved in the study.

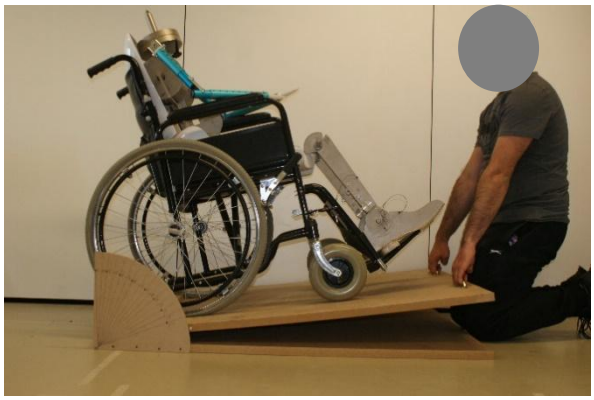
A total of 42 wheeled mobility aids were tested (both manual and powered mobility aids) under two conditions: unoccupied and 'occupied' with a weighted mannequin. The weighted mannequin weighed 25kg representing a 50th-percentile woman. As explained in Section 17.1.1 heavier weights could not be used due to health and safety risks to the research team.

To collect data, the following process was performed:

1. The weight of the unoccupied wheeled mobility aid was recorded.
2. The wheeled mobility aid was placed on an elevating platform - starting level with no gradient (horizontal) - and raised at 10-degree increments until the tipping point was achieved.

3. Step 2 was carried out for both posterior (backwards) tipping[55] and lateral (side) tipping[56] of the wheeled mobility aid to establish both the main gradient and effect of crossfalls (see Table 75).
4. The tipping point was recorded as an angle[57]. Angles were converted to ratio measures by the LU research team.
5. Step 2-4 was completed for both the unoccupied and 'occupied' wheeled mobility aid.

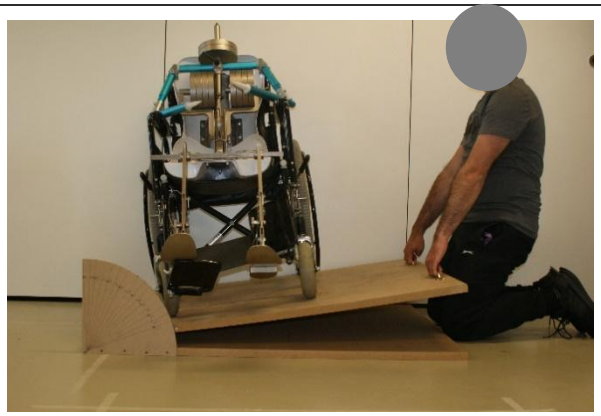
Table 75. Tipping data study photographs.

Measurement	Picture
Posterior / Backward (Empty)	
Posterior / Backwards (Weighted)	

[55] Posterior tipping was tested as this typically applies in relation to ascending a ramp.

[56] Lateral tipping was tested as this typically applies in relation to the crossfall of a ramp.

[57] This was done to align with current guidance (see Section 3.2).

Measurement	Picture
Lateral / Side (Empty)	
Lateral / Side (Weighted)	

17.3.1 Sample

Table 76 shows the number of wheeled mobility aids tested in the study by mobility aid type.

Table 76. Tipping data study- wheeled mobility aid type.

Wheeled mobility aid type	Number of participants
Manual	30
Powered	12
Total	42

17.4 Findings

17.4.1 Manual mobility aids

The average weight of manual mobility aids was 12.5kg[58].

Table 77 shows the average tipping gradient for manual mobility aids when unoccupied and 'occupied' for both posterior (back) and lateral (side) tipping.

Table 77. Manual mobility aid - tipping gradients.

Posterior (back) (Average gradient ratio)		**Lateral (side) (Average gradient ratio)**	
Unweighted (Unoccupied)	Weighted ('Occupied')	Unweighted (Unoccupied)	Weighted ('Occupied')
1: 1.6	1: 2	1: 1.1	1: 1.7

From the data set, the average tipping gradient for 'occupied' manual mobility aids (both posterior (back) and lateral (side)) was shallower than when unoccupied.

Some variety was found in the tipping points gradients for both posterior and lateral tipping. For instance, the shallowest recorded gradient for posterior tipping (unoccupied) was 1:2.5 and for posterior tipping ('occupied') was 1:2.9. For lateral tipping, it was 1:1.4 (unoccupied) and 1:2.8 ('occupied').

17.4.2 Powered mobility aids

The average weight for powered mobility aids was 37.9kg.

Table 78 shows the average tipping point gradient for powered mobility aids when unoccupied and 'occupied'.

Table 78. Powered mobility aid - tipping gradients.

Posterior (Back) (Average gradient ratio)		**Lateral (Side) (Average gradient ratio)**	
Unweighted (Unoccupied)	Weighted (Occupied)	Unweighted (Unoccupied)	Weighted (Occupied)
1: 1.1	1: 1.4	1: 1.3	1: 1.6

From the data set, the average tipping gradient for 'occupied' powered mobility aids (both posterior (back) and lateral (side)) was shallower than when unoccupied).

[58] The average weight of all wheeled mobility aids (42) was 19.6kg.

Some variety was found in the tipping points gradients for both posterior and lateral tipping. For instance, the shallowest recorded gradient for posterior tipping was 1:2.2 for both unoccupied and 'occupied' mobility aids. For lateral tipping, it was 1:2.2 (unoccupied) and 1:2.4 ('occupied').

17.4.3 Manual vs powered mobility aids

Table 79 provides a comparison of the manual and powered mobility aid tipping gradients.

Table 79. Manual vs powered mobility aid tipping gradients.

	Posterior (Back) (Gradient ratio)		**Lateral (Side) (Gradient ratio)**	
	Unweighted (Unoccupied)	Weighted (Occupied)	Unweighted (Unoccupied)	Weighted (Occupied)
Average – manual	1: 1.6	1: 2.0	1: 1.1	1: 1.7
Shallowest – manual	1:2.5	1:2.9	1:1.4	1:2.8
Average – powered	1: 1.1	1: 1.4	1: 1.3	1: 1.6
Shallowest – powered	1:2.2	1:2.2	1:2.2	1:2.4

For posterior (back) tipping gradients, manual mobility aids (both unoccupied and 'occupied) had both a shallower average and shallowest overall tipping gradient compared to powered mobility aids.

For lateral (side) tipping gradients, powered mobility aids (unoccupied) had both a shallower average and shallowest overall tipping gradient compared to manual mobility aids.

When 'occupied', manual mobility aids had a marginally shallower average tipping gradient (lateral (side) compared to powered mobility aids, and the shallowest overall tipping gradient.

17.5 Summary and key findings

The aim of the focus study was to understand the tipping points of unoccupied and 'occupied' wheeled mobility aids on ramps and slopes.

The key findings are:

- It is not clear from the data set if there is a correlation between the weight of a wheeled mobility aid and its tipping point of e.g. do lighter or heaver chairs have shallower or steeper tipping points.

- In this study, tipping data was based on 'occupied' wheeled mobility aids using weighted mannequins in place of users. Future research should test 'occupied' wheeled mobility aids of different weights (i.e. representing larger percentile groups than tested in this study) to better understand the tipping point for different wheeled mobility aid users.
- Further research on movement and tipping should be undertaken to assess the impact on movement.

17.6 Ramp usability study

17.6.1 Data constraints

Due to the COVID-19 pandemic recruitment of participant to attend laboratory spaces at LU to collect data was affected. Therefore, whilst a quantitative study was originally proposed against ramps meeting current standards (with a varying gradient lab set-up), the team instead collected qualitative data at selected locations where ramps would be present and ramp users already present in these spaces.

It has not been possible to conduct full comparison of ambulant disabled use with wheelchair users on ramps as the locations visited had a shortage of ambulant disabled people (e.g. people approached did not want to participate in the study).

The testing sites all have regular ambulant and wheelchair users meaning that many of the gradients where shallow due to the nature of the buildings use. This means that 7 of the 11 surfaces tested would be considered slopes (or gently sloping as per ADM Volume 1 and 2 terminology, i.e. 1:21 or shallower) under current standards rather than ramps (i.e. 1:20 or steeper). Please note we have used 'ramps' for ease throughout this report. Due to onsite data collection methods, it was not safe to erect temporary ramps for data testing to allow testing of each gradient as currently noted in ADM Volumes 1 and 2.

The impacts of crossfalls have been explored in relation to the lateral (side) measurements; however, they have not been considered together in combination with the gradient in the main direction of travel (the posterior, or backward tipping gradient) in this report – this should be noted as an area requiring further research.

17.7 Current design guidance on ramps and slopes

See Section 17.2 for current design guidance on ramps and slopes.

17.8 Methodology

Data collection took place in the built environment at 5 different locations with existing ramps and slopes. A total of 11 ramps and slopes – both external and internal - were measured for the study.

93 participants took part in the study (see Table 80). Participants were obtained in-situ (i.e. people present at the sites were invited by LU researchers to take part in the study). A mixture of wheeled mobility aid users[59], ambulant disabled people participated in the study.

[59] For clarity, wheeled mobility aid users were using their wheeled mobility aid on the day of testing.

To collect data, the following process was performed:

1. The ramp gradient and length were recorded.
2. Participants were asked a list of pre-arranged questions on the usability of the ramp[60].

The data collection template is provided in Section D.7 of Appendix D.

17.8.1 Sample

Table 80 shows the number of participants involved in the study at each location.

Table 80. Ramp study – participants.

	Wheelchair user	Ambulant disabled user (Walking aid user)	Ambulant disabled user (No walking aid)
Location A	12	4	0
Location B	49	0	2
Location C	5	0	0
Location D	7	0	0
Location E	14	0	0
Total	**87**	**4**	**2**

Table 81 shows the gradients of the ramps at each location and the number of participants interviewed.

Both ramps at location E had a 1:29 gradient but were a different length and width. An asterisk (*) is used to distinguish between the two ramps in the data tables.

All but one of the ramps used in the study (Location C, ramp 2: gradient 1:7) met current gradient guidance (i.e. 1:12 – 1:20).

None of the ramps had handrails, thus no observations could be made on their use.

[60] Note, participants where asked questions about the ramp they had used rather than about all ramps in that location, consequently participant numbers per ramp vary.

Table 81. Ramp gradients and participants per ramp.

	Location A Ramp 1	Location A Ramp 2	Location B Ramp 1	Location B Ramp 2	Location C Ramp 1	Location C Ramp 2	Location C Ramp 3	Location D Ramp 1	Location D Ramp 2	Location E Ramp 1	Location E Ramp 2
Gradient	1:24	1:23	1:28	1:27	1:22	1:7	1:14	1:13	1:15	1:29	1:29*
Number of participants: Wheeled mobility aid users	6	6	25	24	1	2	2	4	3	7	7
Number of participants: Ambulant disabled users	2	2	1	1	0	0	0	0	0	0	0

17.9 Findings

The tables presented in this section are organised to reflect the order of questions asked to participants. Data tables are provided in Section D.8 in Appendix D.

Numbers in bold details the largest response number per question[61].

It should be noted that participants were asked to provide feedback on the ramp they were using, therefore the findings from individual ramps cannot be directly compared as each ramp was different.

17.9.1 Ambulant disabled users

Due to the small sample size (6 participants), data from ambulant disabled participants was combined for data analysis.

Comfort of ramp use

Table 82 shows participant responses to the survey question: “How comfortable was the ramp ‘to use’?”

[61] E.g. if there are 4 respondents and 3 responded that the ramp was comfortable and 1 uncomfortable, the 3 would be in bold.

Table 82. Ambulant disabled users - comfort of use.

Ramp gradient	Very comfortable	Comfortable	Neither	Uncomfortable	Very uncomfortable	Total per ramp
1:23	1	0	0	0	1	2
1:24	**2**	0	0	0	0	2
1:27	0	1	0	0	0	1
1:28	0	0	0	0	1	1
Total participants						6

Significant differences in experiences were recorded, with different participants reporting the gradients between 1:23 and 1:28 as “very comfortable” / “comfortable “or “very uncomfortable”.

Effort of ramp use

Table 83 shows participant response to the survey question: “How much effort did that ramp require?”

Table 83 Ambulant disabled users - effort of use

Ramp gradient	Very weak	Weak	Moderate	Strong	Very strong	Extreme	Total per ramp
1:23	0	0	1	0	0	1	2
1:24	0	1	1	0	0	0	2
1:27	0	0	1	0	0	0	1
1:28	0	0	1	0	0	0	1
Total participants							6

Most participants reported the gradients between 1:23 and 1:28 as requiring “weak” or “moderate” effort to use. 1 participant reported the gradient of 1:23 as requiring “extreme" effort to use.

Steepness of ramp[62]

Participants were asked: “In general, do you prefer a shallow longer slope or a steeper shorter slope than the one just completed?”

All participants stated they would prefer a slope that was “longer and shallower”.

Table 84 shows participant responses to the survey question: “Would you be comfortable with a slope that was (a little steeper or a much steeper)?”

[62] Note only 4 of the 6 ambulant disabled participants answered this question.

Table 84. Ambulant disabled users – ramp steepness preference.

Ramp gradient	Little steeper		Total per ramp	Much steeper		Total per ramp
	Y	N		Y	N	
1:23	1	1	2	0	**2**	2
1:24	1	1	2	0	**2**	2
1:27	0	0	0	0	0	0
1:28	0	0	0	0	0	0
Total participants			4			4

For the ramp gradients of between 1:23 and 1:24, half of the participants expressed they would be comfortable with a ramp that was a “little steeper”. However, all participants stated they would not be comfortable with a “much steeper” ramp.

Length of ramp[63]

Table 85 shows participant responses to the survey question: “Would you be comfortable with a slope that was (a little longer or a much longer)?”

Table 85. Ambulant disabled users - length of ramp.

Ramp gradient	Little longer		Total per ramp	Much longer		Total per ramp
	Y	N		Y	N	
1:23	**2**	0	2	0	**2**	2
1:24	1	1	2	1	1	2
1:27	0	0	0	0	0	0
1:27	0	0	0	0	0	0
1:28	0	0	0	0	0	0
1:28	0	0	0	0	0	0
Total participants			4			4

For the ramp gradient of 1:23, all participants stated they would be comfortable with a ramp that was a “little longer”, but not “much longer”.

[63] Note only 4 of the 6 ambulant disabled participants answered this question.

For the ramp gradient of 1:24, half of the participants stated they would be comfortable with a ramp that was “much longer”; however, the other participant stated they would not be comfortable if they ramp was even a “little longer”.

17.9.2 Wheeled mobility aid users

Comfort of ramp use

Table 86 shows participant responses to the survey question: “Was the ramp [e.g. very comfortable, comfortable etc.] to use?”

Table 86. Wheeled mobility aid users - comfort of use.

Ramp gradient	Very comfortable	Comfortable	Neither	Uncomfortable	Very uncomfortable	Total per ramp
1:7	0	1	0	1	0	2
1:13	0	2	2	0	0	4
1:14	1	1	0	0	0	2
1:15	2	1	0	0	0	3
1:22	0	0	0	1	0	1
1:23	1	1	4	0	0	6
1:24	1	5	0	0	0	6
1:27	8	10	2	3	1	24
1:28	6	**15**	0	3	1	25
1:29	1	3	2	1	0	7
1:29*	2	3	0	2	0	7
Total participants						87

Similar to the ambulant disabled participant group, there is no clear link with comfort and gradient in the wheelchair user data set as for all of the ramps except the 1:23 ramp, the majority of participants who tested the ramps stated they found them comfortable to use, with the majority for the 1:23 stating it was neither comfortable nor uncomfortable.

- For the 1:7 ramp: 1 of the 2 participants said it was ‘comfortable’ with the other saying it was uncomfortable - note this ramp would not be compliant under current recommendations.
- For the 1:13 ramp: 2 of the 4 participants said it was ‘comfortable’ to use with the other 2 saying it was neither comfortable nor uncomfortable to use.
- For the 1:14 ramp: 1 of the 2 participants said it was ‘comfortable’ with the other saying it was ‘very comfortable’.
- For the 1:15 ramp: 2 of 3 participants said they found the ramp to be ‘very comfortable’ with 1 saying it was comfortable.
- For the 1:22 ramp: the only participant said they found it ‘uncomfortable’ to use.
- For the 1:23 ramp: 4 of the 6 participants for this ramp stated they found the ramp neither comfortable nor uncomfortable to use.
- For the 1:24 ramp: 5 of the 6 participants for this ramp found it to be ‘comfortable’ with 1 finding it very comfortable to use.
- For the 1:27 ramp: 10 of the 24 of participant’s found this to be ‘comfortable’ to use with 9 finding it ‘very comfortable’ to use.
- For the 1:28 ramp: 15 of the 25 of participants for this ramp found it to be ‘comfortable’ to use.
- For the 1:29 ramp: most people said they found it ‘comfortable’ to use.
- For the 1:29* ramp: most people said they found it ‘comfortable’ to use.

Effort of ramp use

Table 87 shows participant response to the survey question: “How much effort did that ramp require?”

Table 87. Wheeled mobility aid users – effort of use.

Ramp gradient	Very weak	Weak	Moderate	Strong	Very strong	Extreme	Total per ramp
1:7	0	1	0	0	0	0	1
1:13	0	0	2	0	0	0	2
1:14	0	0	2	0	0	0	2
1:15	0	2	0	0	0	0	2
1:22	0	0	1	0	0	0	1
1:23	0	1	1	3	1	0	6
1:24	1	0	4	1	0	0	6
1:27	4	3	11	2	4	0	24
1:28	1	6	**12**	3	2	1	25
1:29	0	0	5	1	1	0	7
1:29*	0	0	6	1	0	0	7
Total participants							85

When looking at effort required most participants responded that they required moderate levels of effort across all gradients except for the 1:7, 1:15 and 1:23.

For the 1:7 the only participant said the ramp required weak effort, for the 1:15 both participants said the ramp required weak effort and for the 1:23 the majority of participants stated it required strong effort.

- For the 1:7 ramp: the only participant said they found this required a ‘weak’ level of effort to use the ramp.
- For the 1:13 ramp: 2 of 2 participants said they required a ‘moderate’ level of effort to use the ramp.
- For the 1:14 ramp: 2 of 2 participants said it required ‘moderate’ levels of effort to use the ramp.
- For the 1:15 ramp: 2 of 2 participants said the ramp required a ‘weak’ level of effort to use the ramp.
- For the 1:22 ramp: 3 of 6 participants said they found the ramp to require ‘strong’ effort, with 1 saying ‘very strong’ levels of effort, 1 requiring ‘weak’ levels of effort, and 1 requiring ‘moderate’ levels of effort to use the ramp.

- For the 1:23 ramp: 3 of the 6 participants for this ramp stated they found the ramp to require ‘strong’ levels of effort to use the ramp.
- For the 1:24 ramp: 4 of the 6 participants for this ramp stated they found the ramp to require ‘moderate’ levels of effort to use the ramp.
- For the 1:27 ramp: 11 of the 24 of participants for this ramp found the ramp to require ‘moderate’ levels of effort to use the ramp.
- For the 1:28 ramp: 12 of the 25 of participants for this ramp sated they found it required ‘moderate’ levels of effort to use the ramp.
- The 1:28 ramp was the only one of the ramps in which a participant said required ‘extreme’ levels of effort to use the ramp.
- For the 1:29 ramp: 5 of 7 found the ramp to require ‘moderate’ levels of effort to use the ramp.
- For the 1:29* ramp: 6 of 7 participants found they required ‘moderate’ levels of effort to use the ramp.

Steepness of ramp

Participants were asked: “In general, do you prefer a shallow longer slope or a steeper shorter slope than the one just completed?”

There was an overall preference for longer and shallower ramps from the participants that answered this question across all the gradients.

- For the 1:7 ramp: 1 of 2 participants said they would prefer ‘longer shallower’ ramp with the other saying they would prefer a ‘shorter steeper’ ramp.
- For the 1:13 ramp: all 4 participants said they would prefer a ‘longer shallower’ ramp.
- For the 1:14 ramp: 1 of 2 participants said they would prefer a ‘longer shallower’ ramp with the other saying they would prefer a ‘shorter steeper’ ramp.
- For the 1:15 ramp: all 3 participants said they would prefer a ‘longer shallower’ ramp.
- For the 1:22 ramp: the only participant said they would prefer a ‘shallower longer’ ramp.
- For the 1:23 ramp: 6 out of 6 said they would prefer a ‘longer shallower’ ramp.
- For the 1:4 ramp: 6 out of 6 said they would prefer a ‘longer shallower’ ramp.
- For 1:27 ramp: 20 of 22 that answered this question said they would prefer a ‘longer shallower’ ramp.
- For 1:28 ramp: 22 of 24 that answered this question said they would prefer a ‘longer shallower’ ramp with 2 of 24 answering they would prefer a ‘shorter steeper’ ramp.
- For the 1:29 ramp: 6 of 6 participants said they would prefer a ‘longer shallower’ ramp.
- For the 1:29 ramp: 6 of 6 participants said they would prefer a ‘longer shallower’ ramp.

Table 88 shows participant responses to the survey question: “Would you be comfortable with a slope that was (a little steeper or a much steeper)?”.

Table 88. Wheeled mobility aid users - steepness of ramp.

Ramp gradient	Little steeper		Total per ramp	Much steeper		Total per ramp
	Y	N		Y	N	
1:7	1	0	1	0	1	1
1:13	2	2	4	0	4	4
1:14	1	0	1	0	1	1
1:15	2	1	3	0	3	3
1:22	0	0	0	0	0	0
1:23	1	5	6	0	6	6
1:24	5	1	6	0	6	6
1:27	10	14	24	4	**20**	24
1:28	7	18	25	5	**20**	25
1:29	4	3	7	0	7	7
1:29*	4	3	7	0	7	7
Total participants			84			84

Most participants stated that they would not be comfortable with a steeper gradient.

- When looking at comfort across all gradients but the 1:24 the majority of participants answered ‘no’ to being more comfortable on a ramp that would be a ‘little steeper’.
- When looking at preference for ‘much steeper’ more participants answered ‘no’ than ‘yes’. For the true ramp gradients (1:7, 1:13,1:14 and 1:15) all participants that answered this question said no they would not be more comfortable on a ramp that was ‘much steeper.

Length of ramp

Table 89 shows participant responses to the survey question: “Would you be comfortable with a slope that was (a little longer or a much longer)?”

Table 89. Wheelchair users - length of ramp.

Ramp gradient	Little longer		Total for ramp	Much longer		Total per ramp
	Y	N		Y	N	
1:7	0	1	1	0	1	1
1:13	2	2	4	1	3	4
1:14	0	1	1	0	1	1
1:15	1	2	3	1	2	3
1:22	0	0	0	0	0	0
1:23	5	1	6	2	4	6
1:24	5	1	6	2	4	6
1:27	13	11	24	3	21	24
1:28	15	10	25	2	**23**	25
1:29	4	3	7	0	7	7
1:29*	4	3	7	0	7	7
Total participants			84			84

For all of gradients, most participants said ‘yes’ to a ramp that was a ‘little longer’.

- For the 1:7 ramp: the only participant for this ramp said ‘no’ they would not be comfortable with the ramp a ‘little longer’.
- For the 1:13 ramp: 2 of 4 participants said ‘yes’ they would be comfortable with the ramp a ‘little longer’ with the other 2 saying ‘no’ they would not.
- For the 1:14 ramp: the only participant said ‘no’ they would not be comfortable with the ramp a ‘little longer’.
- For the 1:15 ramp: 2 of the 3 participants stated ‘no’ they would not be more comfortable on a ramp that was a little longer with 1 stating ‘yes’ they would.
- For the 1:23 ramp: 5 of the 6 participants stated ‘yes’ they would be comfortable with the ramp to be a ‘little longer’ and 1 responded ‘no’ they would not.
- For the 1:24 ramp: 5 of the 6 participants stated ‘yes’ they would be comfortable with the ramp to be a ‘little longer’ with 1 stating ‘no’ they would not.
- For the 1:27 ramp: 13 of the 24 participants stated ‘yes’ they would be comfortable with the ramp to be ‘much longer’, with 11 stating ‘no’ they would not.

- For the 1:28 ramp: 15 of the 25 participants stated ‘yes’ they would be comfortable with the ramp to be ‘much longer’, with 10 stating ‘no’ they would not.
- For both the 1:29 and 1:29* ramps: 4 participants out of 7 stated ‘yes’ they would be comfortable with the ramp it a ‘little longer’ and 3 stated ‘no’ they would not.

For all of gradients, most participants said ‘no’ to a ramp that was ‘much longer’.

- For the 1:7 ramp: the only participant stated ‘no’ to having the ramp ‘much longer’
- For the 1:13 ramp: 3 of 4 participants stated ‘no’ to having the ramp ‘much longer’, with 1 responding ‘yes’.
- For the 1:14 ramp: the only participant stated ‘no’ to having the ramp ‘much longer’.
- For the 1:15 ramp: 2 of the 3 participants stated ‘no’ to having the ramp ‘much longer’ with 1 responding ‘yes’.
- For the 1:23 ramp: 4 of the 6 participants stated ‘no’ to the ramp being ‘much longer’ and 2 responded ‘yes’, they would.
- For the 1:24 ramp: 4 of the 6 participants stated ‘no’ to the ramp being ‘much longer’ and 2 responded ‘yes’ they would.
- For the 1:27 ramp: 21 of the 24 participants stated ‘no’ they would not like the ramp to be ‘much longer’ and 3 responded ‘yes’ they would.
- For the 1:28 ramp: 23 of the 25 participants stated ‘no’ they would not like the ramp to be ‘much longer’ and 2 responded ‘yes’ they would.
- For both the 1:29 and 1:29* ramps: all participants for these ramps stated ‘no’ they would not want the ramp to be ‘much longer’.

17.10 Key findings and summary

The aim of the focus study on ramps was to understand disabled people’s experience of using ramps.

- Due to the size of this study it was not possible to test the experiences of a wide range of ambulant disabled people. This is an area that should be explored in future research to better understand the needs of non-wheelchair users on ramps and slopes and where there is a preference for the use of steps.
- This study focused on qualitative data however it would be beneficial in future studies that a mixed method study with both qualitative and quantitative data is employed to be able to quality factors such as ideal length of ramps.
- In lab testing to review a range of ramps against the current guidance and standards under both wet and dry conditions would help better understand if standards should vary in the internal and external environments.

It is recommended that further studies testing of the suitability of handrail heights and profiles is undertaken, especially in relation to use by ambulant disabled users.

18. Conclusion

This Part M research was undertaken to understand the requirements of the population in England in relation to the built environment, in particular disabled people and people with long-term health conditions. The intention of this research was to inform an update to Approved Document M (ADM) (Volumes 1 and 2) which provides statutory guidance on how to meet the requirements of Part M of the Building Regulations.

The key aims of the research were to:

- Understand what current evidence, data and research exists about the population in England, in particular disabled people and people with long-term health conditions.
- Produce new, up-to-date experimental and qualitative data, about the requirements of disabled people and people with long-term health conditions.
- Provide findings and identify recommendations or areas for future research for the Department for Levelling Up, Housing and Communities to consider as part of any updates to ADM (Volumes 1 and 2).

The research was split into 3 Objectives, consisting of 12 Research Streams in total, that involved:

- A literature and data review to establish the current evidence base and identify gaps in knowledge.
- Qualitative data collection (survey, interviews and focus groups with disabled people and people with long-term health conditions) and quantitative ergonomic and anthropometric data collection on disabled people and their wheeled mobility aids.
- Focus studies, collecting data to support four priority research areas identified by DLUHC.

The findings from the research indicate that the spatial dimensions for access provided in current guidance, including ADM (Volumes 1 and 2), are generally too small for a wide range of disabled people and people with long-term health conditions.

Disabilities are often treated separately in design guidance, but co-occurrence of disability is high. Disabled people often also use more than one type of mobility aid. This means disabled people's spatial needs are complex. Despite this, designing for access tends to focus primarily on independent wheeled mobility aid users.

This research indicates that people's spatial needs are also significantly influenced by other factors, including being accompanied by companions (e.g. assistants; family; children etc.); personal adaptation / additions to wheeled mobility aids; using additional mobility aids simultaneously; individual manoeuvring and transfer style etc.

Consequently, significant numbers of disabled people appear to 'put up' with non-accessible spaces, or completely avoid them – people tend to have a good idea of where they can and cannot go. This means access issues with design are likely to go unaddressed.

While a significant number of the key items generally limiting access to the built environment are currently not included within the guidance in ADM (Volumes 1 and 2), they are included in BS 8300 Parts 1 and 2 (but BS 8300 is not currently a statutory building standard).

For robust studies, accurate and representative population samples / sampling methods are required. However, currently, much of the needed data does not exist. Where data is available, this generally does not capture the complexity of disabled people's requirements (e.g. knowing someone has a mobility-related disability does not identify whether they use a wheeled mobility aid) or record the number of mobility aids they may own and use.

Therefore, while a useful starting point to inform a possible update to Part M of the Building Regulations, the data collected about, and from, disabled people in this research is not comparable to the extensive data sets and research that informs our understanding of design for non-disabled people. The data gaps identified about disabled people and their experiences of the built environment in this research needs to be addressed (considering the evolving range of non-disabled people ergonomic range also) to best understand what is required to provide an accessible built environment for all.

Focused ergonomic studies that consider both how we design specific spaces (e.g. sanitary facilities, kitchens, etc.) and the features of the built environment (i.e. ramps, doors, and controls etc.) also need to be conducted with a range of actual users - rather than extrapolated from anthropometric data - and co-designed with users, to build up more robust guidance.

18.1 Future research recommendations

Demographic data and disability prevalence

- Data collection to fill data gaps and improve the accuracy of existing data. Key areas relevant to the design of the built environment include:
  - Current and future projections (for the next 5, 10 and 20 years) of population demographics, including transgender and non-binary people, and disabilities and long-term health conditions, including neurodivergence and mental health conditions, sensory disabilities and learning disabilities.
  - Research on the co-occurrence of disabilities and the prevalence of disability and long-term health conditions within different demographic groups, including ethnic groups, and older and younger people.
  - Number of people with assistance animals / emotional support animals.
  - Number of pregnant people at any one time, and to consider how pregnancy prevalence interacts with disability. Further medical or qualitative research to understand how different stages of pregnancy create different accessibility needs in the built environment.
  - Estimated population who would benefit from the space and / or facilities provided by Changing Places toilets.
  - Estimated population requiring assistance. Research could also be conducted in public locations to understand the number of people who travel with assistance or require assistance outside their homes.
  - Estimated population who have caring for children responsibilities and research to understand how the care of children impacts on the built environment, whether in people's homes or in buildings other than dwellings.
- Improving data collection methods to:

- Allow people to identify themselves more accurately in surveys and research – e.g. allowing respondents to select multiple disabilities or health conditions to more accurately identify disability prevalence in the population.
- Clarify definitions e.g. what is meant by illness, to improve the accuracy and comparability of data.
- Collect data on the number and range of aids used by individuals to identify space needed for storage.

Ergonomic data

- Future rolling ergonomic studies to understand both the prevalence of, and to consider the needs of:
  - Wheelchair and wheeled mobility aid users.
  - Ambulant disabled people and semi-ambulant mobility aid users.
  - People with limited strength and dexterity.
  - People with assistance animals.

Building data

- Data collection to understand the existing and proposed / future building stock in England. Key areas relevant to accessibility include:
  - Number and distribution of M4(3) Category 3 Wheelchair user dwellings and M4(2) Category 2: Accessible and adaptable dwellings.
  - Number and distributions of accessible parking facilities (as per the current requirements of ADM Volume 2).

Specific research projects

- Establishing manoeuvrings spaces required for a wider range of people including those using mobility aids such as walking frames or long canes, and guide dogs. Including space to pass and travel a set distance.
- The effectiveness of LRV values and the relative light levels needed to ensure sufficient contrast is provided for a wide range of users
- A review of the height and design of door thresholds and the impact of their design on wheelchair users and a wide range of disabled people
- Toilet design and the layouts and facilities required by a wide range of disabled people. This should include positioning of the basin in relation to the WC and the availability and use of grab rails.
- Reach range data to inform use of specific facilities such as petrol pumps and electric charging points.
- Reach ranges for ambulant disabled people focusing on heights and in particular the lower end of the reach range and the use of letter boxes and picking up letters.
- Further study to assess the depth of reveal that can be provided to doors to allow access to handles (currently not specified in guidance except in ADM Volume 1 for a M4(3) Category 3: Wheelchair user dwelling).

- Data set which detailed if wheelchair users were in manual or powered wheelchairs as well as additional questions to assess any co-occurrence of disabilities, to explore if there is any impact on operation of doors based on chair type.
- Research into the use of door and window handle types / profiles and suitability of current guidance on handle design. This should include locking facilities on doors.
- Research into the use and operation of sliding doors and the space requirements to operate.

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