STUDY 1

Incorporating minimum accessibility standards in new housing: A survey of access consultants and architects

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SUMMER FOUNDATION

LA TROBE UNIVERSITY

The Summer Foundation is a not-for-profit organisation, established in 2006, that aims to change human service policy and practice related to young people in nursing homes. Our mission is to create, lead and demonstrate long-term sustainable changes that stop young people from being forced to live in nursing homes because there is nowhere else for them.

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Foreword

The Summer Foundation is very pleased to present ***Incorporating minimum accessibility standards in new housing: A survey of access consultants and architects***.

This report is the first of 2 studies commissioned in November 2020 and conducted through the Summer Foundation – La Trobe University Research program. These reports provide an evidence base to inform decision-makers on incorporating minimum mandatory accessibility standards in the 2022 National Construction Code (NCC).

Later this year, Australia's Building Ministers will decide what our next NCC will look like. Their decisions will determine how accessible our houses are for decades to come, and in turn affect the housing needs of those with – or likely to have – mobility limitations. Ministers will be choosing between the current voluntary accessible design guidelines, or new accessibility standards. The opt-in approach has been in place for over a decade and has failed to deliver the promised supply of accessible homes.

Within 40 years, the number of Australians with mobility issues is estimated to almost double from 3 million to nearly 6 million.

The recent report from the Royal Commission into aged care revealed that institutional housing for the elderly is not working. When coupled with the challenges experienced by the aged care sector during the COVID-19 pandemic, the importance of enabling our seniors to remain in their own homes for as long as they want to is clear.

Research shows that up to 80 per cent of Australians aged over 55 want to live at home and "age in place". A recent survey by the University of Melbourne found that over 70 per cent of 1,000 Australians with mobility limitations live in housing that did not meet, or only partly met their accessibility needs. Some of this shortfall in suitable housing can be rectified by incorporating mandatory minimum accessibility standards in the NCC. Only a mandatory approach will future-proof Australia's housing for coming generations and cater to the demands of an ageing population.

This report finds that numerous accessible design features – which are crucial for those with mobility limitations – are neither expensive nor difficult to include in most new homes. Including these as mandatory standards in the NCC is common sense.

The Australia we want is one where mobility limitations should not determine where we can live. Making Australia's housing future-proof means pre-empting demand for more accessible housing now. Housing is critical social infrastructure that is with us for decades, so it is vital to get it right.

Di Winkler PhD AM
CEO & Founder, Summer Foundation

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Executive Summary

This study aims to provide an evidence base to inform the specific features being considered for inclusion as minimum accessibility standards in the 2022 National Construction Code (NCC). Accessible features include a level entrance, door and corridor widths, space in front of the toilet pan and features that allow for future adaptation, such as reinforcement of bathroom walls. Incorporating accessible features in the NCC will have a wide range of benefits for the estimated 3 million Australians living with mobility limitations. However, to date there has been little systematic evidence available on the cost and difficulty of including specific features in all new dwellings.

This study fills this gap by seeking the expert opinions of architects and access consultants on how expensive and complicated it would be for builders to incorporate accessible features into all new homes. Experts were asked to rate the cost and difficulty of 28 accessible features in new houses, apartments, and townhouses. A total of 24 architects and access consultants completed an online survey between December 2020 and January 2021.

The survey revealed that 12 of the 28 accessible features are easy and inexpensive (or cost-neutral) to incorporate across all new dwellings. Some of these include common sense design features such as the height of light switches, or the style of door handles and taps. Furthermore, features that are more costly or difficult to incorporate in one type of dwelling may be inexpensive and simple in another. For example, including a toilet or shower on the ground floor of houses is lower cost and difficulty than including the same in a townhouse. Architects and access consultants repeatedly stated that including accessible features during the design phase of new builds is the best way to ensure cost effectiveness. This design-led approach to incorporating minimum accessibility standards would reduce the cost impact and improve the overall design of new homes.

Australian homes are some of the biggest in the world, and the majority of these are stand-alone houses. Respondents to this survey noted the challenge of including accessible features in more complex sites, such as townhouses with 2 or more storeys. However, these more challenging sites are only a small proportion of all Australian homes, which means that implementing accessibility standards through a design-led approach is very achievable.

The findings of this survey indicate that a design-led approach to incorporating minimum accessibility standards into new homes can accommodate accessible features with minimal extra cost or impact on amenity. Furthermore, accessibility standards are likely to incur a one-off cost rather than an ongoing cost as the building sector adapts to building houses that are thoughtfully designed and future-proof. These findings suggest that given a design-led approach, many accessible design features under consideration by the Australian Building Code Board (ABCB) for inclusion in the NCC would not be difficult or costly to include in new houses, apartments and townhouses. Many of the homes built today will still be in use in 50 or more years. Australia needs quality housing that is fit-for-purpose and adaptable to the needs of an ageing population rather than housing that will become functionally obsolete.

Introduction

A significant proportion of Australians live with mobility limitations and this number is expected to rise, given the country's ageing population. As a result, the number of people requiring accessible housing is expected to dramatically increase over the next 40 years (CIE, 2020). The cost of aged care is expected to increase from 0.9% to 1.7% of GDP, or $620 to $2,000 per person, by 2055 (Commonwealth of Australia, 2015). The ability to age in place has the potential to provide significant economic benefits, but only if housing is designed to meet the needs of our ageing population.

The Australian Building Codes Board (ABCB), responsible for developing codes and standards, has been conducting a national assessment of options for incorporating minimum accessibility standards into all future dwellings. The Board commissioned the Centre for International Economics (CIE) to develop a consultation Regulation Impact Statement (RIS), which involved an impact analysis on incorporating accessible housing requirements into the NCC (CIE, 2020). The impact analysis involved a description of the extent of the problem, intended outcomes, a range of possible policy changes to achieve these outcomes, a cost-benefit analysis of these options, and consultation with key stakeholders. The potential options for changes were benchmarked against a status quo, no-change scenario. Ultimately, the aim of this analysis was to identify the option that has the greatest cost-benefit for the stakeholders and communities involved. The results of this RIS will provide the ABCB with an analysis of options to inform nationwide standards which will be decided in 2021 and come into effect by September 2022.

The initial CIE analysis concluded that the costs of regulating for mandatory minimum accessibility standards through the NCC would exceed the benefits. It recommended continuation of the current voluntary code of practice. However, the building industry has operated for over a decade under a voluntary code aiming to make all new housing more accessible by 2020. This voluntary approach has failed. Furthermore, an independent review conducted by Dalton and Carter (2020) found that the CIE cost-benefit analysis underestimated the economic benefits of minimum accessibility standards to the whole of society.

Incorporating accessibility standards will have a wide range of benefits for Australians living with mobility limitations. A recent survey examining the lived experience of people with mobility limitations showed that over 70% of respondents were living in housing that does not adequately meet their accessibility needs (Wiesel, 2020). This was particularly prevalent for people with lower support needs, lower incomes, or people living in private rentals. The study highlighted the limited pool of accessible housing options currently available, and the lack of affordability of necessary home modifications, especially for those with high support needs. Additionally, post-construction modifications to inaccessible housing were found to only partially meet the accessibility needs of most respondents, highlighting the importance of designing homes that are adaptable and future-proof.

Many negative effects of living in inaccessible housing were identified by Wiesel (2020), ranging from additional time and energy spent navigating inaccessible homes to difficulties in employment and social opportunities. An overwhelming proportion of participants reported that inaccessible housing has a significant impact on their mental health, especially for those with low support needs. The author concluded that improvements in specific design features could lead to a range of beneficial impacts on the "dignity, freedom, social inclusion, economic productivity, health, and wellbeing" (Wiesel, 2020; pg.7) of people living with mobility limitations.

Currently, there is limited research on the impact of incorporating specific accessible design features into future property developments. Therefore, this study obtained the expert opinion of access consultants and architects on the cost and difficulty of incorporating specific accessible features into the design of all new dwellings. Between December 2020 and January 2021 an online survey completed by 24 architects and access consultants asked experts to rate the relative cost and difficulty of including 28 accessible features in new dwellings. These features were derived from Livable Housing Australia's Design Guidelines (2017), which are the standards under consideration by the ABCB for possible inclusion in the NCC.

Survey respondents rated nearly half of the features as being both "not difficult at all" and "virtually cost neutral" to include across all types of new housing. This indicates that a substantial proportion of the accessible features could be feasibly incorporated as mandatory minimum accessibility standards. However, there were differences in the ease and cost of incorporating some features into different dwelling types, based on considerations such as the number of storeys in the dwelling, or its total size. According to the Australian Bureau of Statistics (ABS) Census 2016, a vast majority of occupied private dwellings in Australia are separate houses (71%), followed by semi-detached row, terrace or townhouses (13%) and apartments (14%) (see Table 1). In terms of the share of the population, nearly 80% of Australians live in a separate house, while approximately 10% live in townhouses and apartments respectively (ABS, 2017).

Table 1. Occupied private dwellings in Australia, by structure

Structure	Sub-type	Sub-total	Total
Separate house			71%
Semi-detached row, terrace, or townhouse	1 storey 2+ storeys	7.3% 5.5%	13%*
Apartment	1-2 storey 3 storeys 4+ storeys	5.0% 3.7% 5.4%	14%

*Rounded figures for sub-totals may not add to total. Source: ABS Census 2016

Method

This study involved an online survey of architects and access consultants. Surveys were sent to 15 potential participants with expert knowledge who were known to the first author. Respondents were asked for "suggestions of architects or access consultants that would be suitable to complete this survey." A total of 40 email invitations with a link to the survey were sent in December 2020.

The survey was completed between December 2020 and January 2021. The accessible elements evaluated in this study were based on the 15 features in the Livable Housing Australia Design Guidelines, 4th Edition (Livable Housing Australia, 2017). Some of the 15 LHA features have multiple components. This survey broke down the LHA features to generate a list of 28 accessibility features as shown in Table 2. While the provision for a stair-climber is implied in the LHA design element regarding internal stairs by specifying a straight flight with a load bearing wall adjacent, this survey referred explicitly to stair-climbers. In addition to asking about all the elements of the LHA features, an additional design feature in the survey was the provision for a future stair climber or lift as an option for homes that do not have amenities and living areas on the ground floor or entry level. Participants were asked to rate each element on Likert-type scales in terms of difficulty (from 1 = not difficult to 4 = very difficult) and cost (from 1 = virtually cost-neutral to 4 = high cost) of implementation in houses, apartments and townhouses. Additional open-ended questions asked participants to explain the reasons for their ratings, propose potential solutions for cost-effective implementation, and indicate whether standardisation could reduce the costs of the elements over time.

The sample consisted of 24 respondents, of whom 5 fully completed the survey, 18 partially completed the survey, and 1 participant provided only qualitative feedback. Of the respondents, 13 were architects, 7 were access consultants, 1 was both an architect and access consultant, and 3 held qualifications as both architects and occupational therapists. At least 2 of the respondents also had additional expertise with lived experience of disability and were wheelchair users. All of the respondents were thoroughly familiar with the LHA Design Guidelines. The survey took around 2 hours to complete, and participants were offered reimbursement at a rate of $200 per hour for up to 2 hours.[1]

The data was de-identified prior to conducting analyses. All Likert-type questions were quantitatively analysed using *R* and Excel. This involved calculating the average cost and difficulty ratings as well as the frequencies of each rating option for all 28 design elements (refer to Appendix for analyses of each design element). Respondents rated the difficulty of incorporating each design element into houses, apartments and townhouses "not difficult" to "very difficult". Respondents also rated the cost of incorporating each of the design elements into a dwelling from "virtually cost-neutral" to "high cost". These ratings were then multiplied to obtain an overall cost-difficulty rating scale of 1 to 16. All calculations were conducted separately for houses, apartments and townhouses.

[1] As multiple participants only partially completed the quantitative aspect of the survey, missing values for individual design elements ranged from 2.17 to 20.29%. The design feature with the highest non-response rate was provision of future stair-climber or lift, followed by windowsill height. Overall, these missing values only contributed to 11% of the data and therefore were not considered to substantially skew the results. When calculating the aggregated cost-difficulty score, responses that only provided a rating for cost or difficulty were removed.

Descriptive qualitative analyses were also conducted for all open-ended questions. Responses were separately analysed for each design element including respondents' explanations regarding costs and difficulty for each dwelling type, potential cost reduction over time, and cost-effective solutions for incorporating accessibility elements. Additionally, common themes across the design elements were identified.

Table 2. Accessible design features

Design feature	Requirements
1. Step-free pathway to entrance	A safe, continuous, step-free pathway from the street entrance and/or parking area to a dwelling entrance that is level
2. Width of pathway to entrance	A pathway that is at least 1000 or 1100mm wide
3. Step-free entrance to residence	At least 1 step-free entrance into the dwelling and the entrance should be connected to the safe and continuous pathway as specified in feature 1
4. Entrance door width	A clear opening width of entry door of at least 850mm
5. Transition height for different floor surfaces	A maximum transition/threshold height of abutting surfaces of 5 mm
6. Internal door and corridor widths	The widths of the internal doors (820mm) and corridors (1000mm) facilitates comfortable and unimpeded movement between spaces
7. Toilet on ground floor	The ground (or entry) level has a toilet to support easy access for home occupants and visitors
8. Space in front of toilet	The circulation space between front edge of the toilet and arc of door is at least 1200mm
9. Closet toilet walls	Walls either side of the toilet are 900mm or 1200mm from the toilet
10. Toilet in bathroom located in corner	The toilet in a combined bathroom is located in the corner
11. Shower on ground floor	There is a shower on the ground (or entry) level
12. Removable shower screen	The shower screen can be removed
13. Step-free shower entry	The shower is step-free or hobless entry
14. Shower size	The shower is at least 900mm x 900mm
15. Space adjacent to shower	The size of the space adjacent to showers is at least 900mm x 900mm

Design feature	Requirements
16. Reinforcement of bathroom and toilet walls	The toilet and bathroom walls are reinforced to enable future installation of grabrails
17. Internal stairways - no winders	Stairways feature no winders in lieu of landings, adjacent to a wall capable of supporting a handrail
18. Provision for future stair-climber or lift	Where sites have limited floor space at entry level, precluding having amenity on entry level, provision should be made for future fit out. This may be through the option of stairs suitable for fit out with a stair-climber or alternatively, provision for future fit out with a lift. These would need to be demonstrated on drawings to achieve compliance.
19. Kitchen space	Clearance in front of fixed benches and appliances (excluding handles) in kitchen are at least 1200mm
20. Laundry space	The space for a washing machine is at least 600mm in depth
21. Ground (or entry) level bedroom space	There is a space on the ground (or entry) level that can be used as a bedroom. (Minimum size of 10m2, excluding wardrobes, linings, etc. There is natural light and ventilation, a bed space of at least 1520mm x 2030mm, plus 1000mm minimum path of travel
22. Height of switches	Light switches are located at heights that are easy to reach for all home occupants (900-1100mm above floor)
23. Height of power outlets	Power outlets are located at heights that are easy to reach for all home occupants (300mm above floor)
24. Height of door handles	Door handles are located at heights that are easy to reach for all home occupants (900-1100mm above floor)
25. Door hardware	Doors feature Lever or D-pull handles
26. Tap hardware	Taps are Lever action
27. Windowsill height	Windowsills are installed at a height that enables home occupants to view the outdoor space from either a seated or standing position (maximum height 1000mm)
28. Slip-resistant flooring	Floor coverings are slip resistant to reduce the likelihood of slips, trips and falls

Results

The cost-difficulty ratings for all 28 design features demonstrate that several features are neither difficult nor costly to incorporate into new houses, apartments and townhouses (see Table 3).[2] The scores ranged from 1.00 to 6.31 (possible range of 1 to 16). Accessible features with the lowest cost-difficulty rating across all dwelling types were the heights of switches and power outlets, as well as door hardware. The feature with the highest cost-difficulty rating was the provision for a future stair-climber or lift across all dwelling types, with the score ranging from 3.18 to 6.31.

"12 accessible features were rated as being easy and inexpensive to incorporate across all new dwellings"

In total, 12 accessible features were rated as being easy and inexpensive to incorporate across all new dwellings. In addition to these 12 features, another 3 features received cost-difficulty ratings ranging from 2.0 to 2.95 across all dwellings (removable shower screens, transition height of different floor surfaces, and reinforcement of bathroom walls).

Furthermore, some accessible features that were more difficult or costly in 1 dwelling type may have been inexpensive and simple in another. For instance, a step-free entrance to the place of dwelling feature was seen as difficult and costly in houses and townhouses but received a low cost-difficulty score for apartments. Equally, while including a toilet or shower on the ground floor of houses and apartments was rated as moderately low difficulty and cost, it is more difficult and costly in townhouses.

Box 1. Features with the lowest cost-difficulty ratings across all dwelling types

Width of pathway to entrance	**Entrance door width**
Toilet in bathroom located in corner	**Shower size**
Laundry space	**Height of switches**
Height of power outlets	**Height of door handles**
Door hardware	**Tap hardware**
Windowsill height	**Slip-resistant flooring**

[2] Full results are available in the Appendix.

Table 3. Cost-difficulty ratings of incorporating accessible features into new dwellings (1 = not difficult/virtually cost neutral; 16 = very difficult/high cost), ranked lowest to highest for houses

Design feature	House↑↓	Apartment	Townhouse
22. Height of switches	1.00	1.00	1.00
23. Height of power outlets	1.00	1.00	1.00
25. Door hardware	1.00	1.00	1.00
24. Height of door handles	1.05	1.00	1.00
20. Laundry space	1.05	1.16	1.05
26. Tap hardware	1.11	1.11	1.11
27. Windowsill height	1.28	1.45	1.45
14. Shower size	1.37	1.61	1.49
4. Entrance door width	1.39	1.44	1.44
10. Toilet in bathroom located in corner	1.74	1.86	1.90
2. Width of pathway to entrance	1.77	1.66	1.78
28. Slip-resistant flooring	1.84	1.84	1.84
10. Toilet on ground floor	2.22	2.00	3.19
11. Shower on ground floor	2.22	2.07	5.38
12. Removable shower screen	2.22	2.28	2.28
15. Space adjacent to shower	2.29	3.92	3.80
5. Transition height for different floor surfaces	2.48	2.28	2.48
21. Ground (or entry level) bedroom space	2.51	2.76	4.60
13. Step-free shower entry	2.51	3.43	3.08
6. Internal door and corridor widths	2.57	2.75	3.25
16. Reinforcement of bathroom and toilet walls	2.66	2.76	2.76
8. Space in front of toilet	2.92	4.73	4.49
17. Internal stairways - no winders	2.94	3.40	4.32
19. Kitchen space	2.95	4.00	4.52
9. Closet toilet walls	3.13	4.10	4.22
3. Step-free entrance to residence	3.24	1.96	3.65
1. Step-free pathway to entrance	3.47	2.43	4.20
18. Provision for future stair-climber or lift	5.38	3.18	6.31

Legend • 1 | • 2 | • 3 | • 4 | • 5 | • 6+

While the quantitative findings above indicate the relative cost and difficulty of incorporating accessible design features in new dwellings, qualitative responses from architects and access consultants allow for a more in-depth understanding of each feature. Below, the quantitative and qualitative results for each of the 28 features are summarised. In general, respondents emphasised that incorporating accessible elements during the design stage would make them easier and less expensive or cost-neutral to include. Several accessible features were recognised as already being standard industry practice, while others were considered to be important to include in future dwellings.

"Several accessible features were recognised as already being standard industry practice"

1. Step-free pathway to entrance

Including a safe, continuous step-free pathway to the entrance of homes was considered less costly and difficult for apartments than for houses and townhouses (Houses = 3.47; Apartments = 2.43; Townhouses = 4.20). This was because it was noted that this element was already incorporated into design for apartments, since they "must comply with existing access to premises requirements" (Commonwealth of Australia, 2010). This contrasted with the comments for houses and townhouses, because the topography of sites was seen as a factor increasing cost and difficulty. While for apartments the requirement was "very simple and a default in nearly all cases", a step-free pathway was "more difficult to solve on sloping sites with small frontages and limited site area".

Image 1. A safe, step-free path and entrance to home with wide door (Courtesy of Parent to Parent Assoc. QLD - P2P Housing Team)

2. Width of pathway to entrance

Respondents ranked the width of pathways to dwelling entrances as an accessible feature that was neither difficult nor expensive (Houses = 1.77; Apartments = 1.66; Townhouses = 1.78). This was partly because pathways with the required width of 1000mm were considered to already be "standard and normal practice" and because they were a minor change that could be "achieved simply". Driveways are also a pathway and are required by planning legislation. One respondent reported that "the cost of concrete is small compared with the benefits of standardisation and the long-term advantages and increasing demand, for wider pathways".

3. Step-free entrance to residence

Having at least one step-free entrance into the dwelling was found to be easy to incorporate in the design stage, but with some attention needed to manage drainage (Houses = 3.24; Apartments = 1.96; Townhouses = 3.65). For houses, it would often be a “minor change” for path and floor levels to match, provided that the feature is included “in the early stages of the design process”. However, it was also noted that this element would be more difficult to implement in certain circumstances, depending on topography, since it would be “more easily achieved on a flat block” than a steep one.

4. Entrance door width

The width of entrance doors to dwellings was one of the 12 elements considered to be neither difficult nor expensive to include (Houses = 1.39; Apartments = 1.44; Townhouses = 1.44). The required entrance door width is also easy to incorporate at the design stage as it is a “relatively straightforward, minor item”. Respondents reported that an entrance with a “850mm clear width should be the new minimum” and was already “fairly standard and common” in apartments. One respondent commented that “where a wider door is used with a corresponding increase in material cost, there is less corresponding wall construction - hence cost neutrality”. Another respondent said that “a 850mm clear opening width of a door is achieved by using a 920mm door leaf. A 920mm door leaf is considered reasonably standard and available off the shelf. The cost difference between a 820mm and 920mm is absolutely minimal, and labour installation cost is cost neutral. 920mm door leafs are now commonly used in commercial construction due to NCC compliance of AS1428.1(2009) requiring a 850mm minimum clear opening width (920mm door).”

Image 2a. At least one step-free entry door *(Courtesy of Stockland)*

Image 2b. Wide step-free entrance with grate to manage drainage *(Courtesy of Kev Morris Builder)*

5. Transition height for different floor surfaces

Achieving a transition of 5mm or less between different floor surface materials can be achieved easily through inclusion at the design stage and is ranked as being relatively straightforward and not very expensive (Houses = 2.48; Apartments = 2.28; Townhouses = 2.48). Architects and access consultants noted that “the heights of respective floor finishes can be designed to achieve minimal transitions”. Furthermore, “where there are horizontal gaps … these can be accommodated by cover strips which are also standard in construction”. The minimal cost of careful design and construction techniques were the reasons given for considering minimising the transition height for different surfaces in homes. As 1 respondent stated, “precise building techniques to obtain correct levels is the most cost-effective approach”. Furthermore, there is also an opportunity to control costs through economies of scale, through the repeated “selection of floor finish thickness across multiple projects".

Image 3. Internal doors that facilitate comfortable and unimpeded movement *(Courtesy of Parent to Parent Assoc. QLD - P2P Housing Team)*

6. Internal door and corridor widths

Increasing the size of internal doors and corridors would generally be “simple to achieve at the design stage” and “should be done as standard” (Houses = 2.57; Apartments = 2.75; Townhouses = 3.25). Most participants reported that door sizes are industry standard and changing door widths would be negligible cost because “a door still is required and the cost of minor width change is negligible”. While there is additional cost associated with a wider door and doorframe, there is also less wall for construction. However, some respondents identified some potential implications for house and lot sizes. One respondent said that “while the ability to make the single lot corridors wider seems easy, the knock-on implications if room sizes are to be retained is that lot sizes in subdivisions all need to increase, [the] land size required increases and the simple can become quite costly”. While wider corridors may have a significant impact on dwellings on smaller sites where the floorplate is constrained, narrow lot homes tend to not have as many corridors and have more open spaces.

Image 4. Internal corridors that facilitate comfortable and unimpeded movement (Courtesy of Stockland Communities)

7. Toilet on ground floor

Providing a toilet on the ground floor or entry level was considered to be a straightforward "issue of placement rather than cost" in some dwellings. As such, it was 1 of the accessible features regarded as being neither overly difficult nor expensive in houses and apartments, but more complex in townhouses (Houses = 2.22; Apartments = 2.00; Townhouses = 3.19). Respondents acknowledged that spatial constraints may impact on placement, but they also commented that "if designed correctly this should not be a problem". Regarding the placement of the toilet, 1 respondent also stated that if "included at design stage there should be no additional cost for a ground floor [toilet] location".

Image 5. Toilet at ground level with adequate space in front of the pan and either side of the toilet (Courtesy of Parent to Parent Assoc. QLD - P2P Housing Team)

8. Space in front of toilet

Designing new homes with greater space in front of a toilet was an accessibility feature that was seen as being more difficult and costly to include in apartments and townhouses than houses (Houses = 2.92; Apartments = 4.73; Townhouses = 4.49). Additional cost may be required for a closet toilet that requires additional width and space in front of the pan. The impact for this feature is only significant in the minority of homes where a closet toilet is the only toilet at entry level. Where a toilet is provided in a bathroom or ensuite, space in front of the pan is usually achieved from shared circulation spaces with other fittings, such as the vanity, shower or bath.

9. Closet toilet walls

This feature relates to when the only toilet provided in a home is within a closet room. As with the space in front of toilets, adequate space on either side of closet toilet walls was seen as moderately difficult and costly to include in new builds (Houses = 3.13; Apartments = 4.10; Townhouses = 4.22). This was partly because the available space and bathroom design was considered a common factor in costing. One respondent said that "in a combined bathroom, the cost is small but in a separate toilet, it requires space" and therefore increases costs. The cost implications were also considered potentially to be different between building types. One respondent said that since apartments tend to be smaller, "anything that requires more space will cost more" compared with larger dwellings. Thus, the impact is greatest where the only toilet is provided in a closet room but reduced if 1 toilet is provided in a bathroom.

10. Toilet in bathroom located in corner

Incorporating a toilet in the corner of a combined bathroom was considered to be reasonably standard practice and therefore added no additional cost. This feature should be neither too difficult nor too costly to include in all dwelling types (Houses = 1.74; Apartments = 1.86; Townhouses = 1.90). One respondent said that it was “already pretty standard in the market” and also easy to achieve if included at the design stage prior to construction.

11. Shower on ground floor

Designing new dwellings to include a shower on the ground floor was considered to be more difficult for townhouses than for apartments and houses (Houses = 2.22; Apartments = 2.07; Townhouses = 5.38). The smaller site sizes attributed to townhouses were seen to influence the ease of providing this element, since it “is easiest for houses and apartments where showers are on the entry level in the majority of the cases”.

12. Removable shower screen

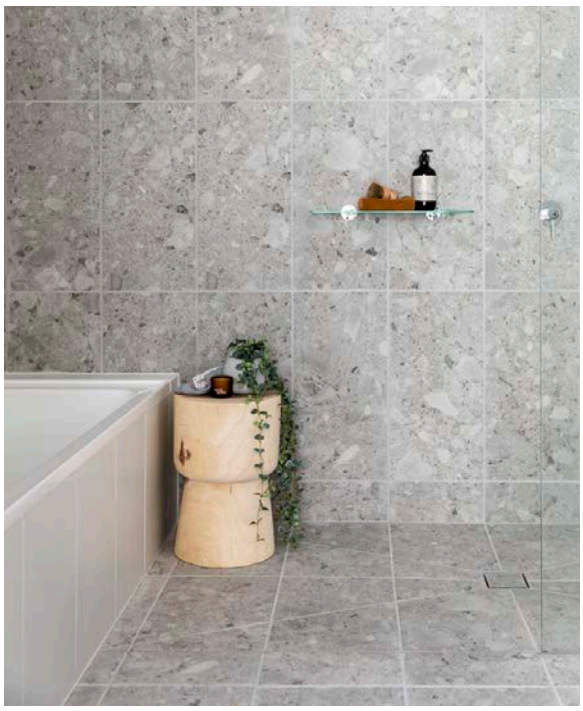
Architects and consultants agreed that the provision of a removable shower screen would not be difficult or costly to include and “generally just a matter of specifying” at the design stage (Houses = 2.22; Apartments = 2.28; Townhouses = 2.28). Further, it could be “a standard feature with the floor and wall finishes continuous behind the screen”. Although there was already a low cost associated with the provision of a removable shower screen, the potential for this to “become cheaper and easier as builders implement” the element through greater adoption was also noted.

13. Step-free shower entry

Making showers more accessible with a step-free or “hobless” entry was seen by some as “already more or less an industry standard [or] becoming an industry standard” despite variations in opinion (Houses = 2.51; Apartments = 3.43; Townhouses = 3.08). Furthermore, including a step-free shower is “easily achieved by having a set down in the floor”. Although achieving level shower entry was considered easy to achieve, the costs were considered to vary depending on construction. One respondent said that “generally, this should be relatively easy to achieve across all dwellings. [However] there may be more cost consideration for engineering within concrete slabs and timber subfloors.”

Image 6. Step-free shower with removable screen (Courtesy of Taylor'd Distinction)

Image 7. Bathroom with slip resistant, hobless shower recess in the corner of the room with a shower screen that can readily be removed at a later date *(Courtesy of Stockland Communities)*



14. Shower size

Standardising a minimum shower size of 900mm x 900mm would mean “little or no change … from a product, material or administrative perspective”, which is why the element was rated as both easily implemented and at low cost (Houses = 1.37; Apartments = 1.61; Townhouses = 1.49). Again, the importance of inclusion at the design stage was noted in order make this “generally simple to achieve … with some increased cost at construction due to size”.

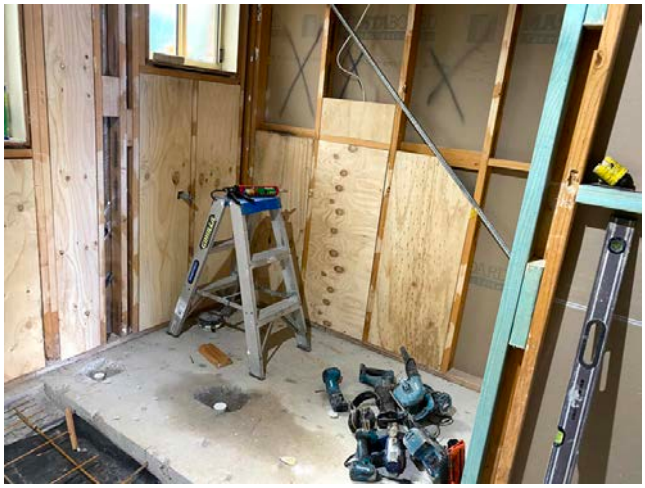
15. Space adjacent to shower

The cost and difficulty of including additional space adjacent to showers varied according to the dwelling type (Houses = 2.29; Apartments = 3.92; Townhouses = 3.80). As 1 respondent explained, additional space “can be more difficult in constrained spaces across each type of building. [The difficulty is] more likely in townhouses and apartments for this reason”.

16. Reinforcement of bathroom and toilet walls

The reinforcement of bathroom and toilet walls during construction to enable future installation of grabrails is a simple but effective strategy to future-proof new homes. However, while simple to achieve, the additional labour and materials were seen to contribute to some additional costs (Houses = 2.66; Apartments = 2.76; Townhouses = 2.76). While reinforcing these walls is not yet standard practice, to do so is “only rudimentary carpentry” with a significant benefit for the later installation of rails. Respondents said that “the installation of noggins in timber frame partitions is very straightforward. If ply is used, this can double as bracing ply.” Others noted that building standards could “specify extra noggins in the wall or use ply to sheet the wall. Builders have decided that the potential for drilling through water pipes is too great [and] would prefer to sheet the wall with ply.”

Image 8. Reinforced walls being built around toilet and shower (Courtesy of Starliner Access Designs)



17. Internal stairways – no winders

The difficulty and cost of including stairways without winders in new dwellings was seen as being context dependent, given the differences between available space across the building types (Houses = 2.94; Apartments = 3.40; Townhouses = 4.32). As 1 respondent noted, the “constraints and costs for this element will be dependent on land size, plus overall dwelling size and design”. Particularly, the cost of no winders in townhouse stairways could be high, due to the typically smaller lot size than for houses.

18. Provision for future stair-climber or lift

Including provision for a future stair-climber or lift was seen as a design element that was more costly and difficult than others (Houses = 5.38; Apartments = 3.18; Townhouses = 6.31). However, it was noted that while a “stair-climber needs a wall capable of the required load”, this could be addressed at the design stage. Provision for a future stair-climber or lift could be an option for some dwellings with limited amenities available on the ground floor. For example, townhouses with more than 1 storey, and where the garage takes up most of the space on the ground floor.

Image 9. Internal stairway designed to reduce the likelihood of injury with adjoining a load bearing wall to enable future adaption (Courtesy of Parent to Parent Assoc. QLD - P2P Housing Team)

19. Kitchen space

Given the space difference across dwelling types, providing additional kitchen space, was considered less costly and difficult for houses (Houses = 2.95; Apartments = 4.00; Townhouses = 4.52). Providing increased clearance between benches in the kitchen was seen to be more difficult in apartments and townhouses as they were perceived to “have significantly different space constraints compared to houses”. The design of kitchens is critical to achieving ample bench length and space in front of benches. Compliance is relatively easy in smaller dwellings with L-shaped benches compared with U-shaped and opposing bench layouts.

20. Laundry space

Achieving adequate space in the laundry for a washing machine 600mm in depth was generally seen to be not difficult or expensive, but “subject to space planning” (Houses = 1.05; Apartments = 1.16; Townhouses = 1.05). Others noted that laundries are a “standard size with plenty of products available”, which explains why it is rated as 1 of the least difficult and expensive design elements to include in all new dwellings.

21. Ground (or entry level) bedroom space

The difficulty and cost of including a room capable of being used as a bedroom on the ground or entry level of new dwellings varied by the type of build (Houses = 2.51; Apartments = 2.76; Townhouses = 4.60). In large part, this was due to the different designs of dwellings, and particularly the fact that currently “double storey homes and townhouses often have living downstairs and bedrooms upstairs”. However, many modern homes already have a flexible space such as a study or living area on the ground floor that could be used as a bedroom.

22. Height of switches

Adjusting the standard height of switches was considered to be 1 of the simple and inexpensive changes to make to building standards (Houses = 1.00; Apartments = 1.00; Townhouses = 1.00). One architect said that this element was “easy and cost effective to achieve but benefits many who need it”.

23. Height of power outlets

In a similar way to the height of switches, modifying the standard height of power outlets to increase accessibility was regarded as neither a difficult nor costly design element to implement in all new builds (Houses = 1.00; Apartments = 1.00; Townhouses = 1.00).

24. Height of door handles

The height of door handles was considered by some to already be a standard industry practice and therefore of no additional cost to incorporate. A respondent reported that the height of door handles “is a reasonably cost neutral regulation”, which explains why it was given such a low cost-difficulty score by architects and access consultants (Houses = 1.05; Apartments = 1.00; Townhouses = 1.00).

25. Door hardware

Changing the standard door hardware in houses was ranked as a straightforward and cost-neutral change since “manufacturers have knob or lever door furniture at near identical supply prices” anyway (Houses = 1.00; Apartments = 1.00; Townhouses = 1.00). However, while this was seen as easy and of little or no cost to include due to the need for door hardware in each project, appropriate specification was seen as important.

26. Tap hardware

Incorporating more accessible tap hardware in new builds was ranked as 1 of the 12 design elements that were effectively cost-neutral and easy to implement (Houses = 1.11; Apartments = 1.11; Townhouses = 1.11). This was primarily due to the fact that the hardware is already standard across the industry.

27. Windowsill height

Adopting as standard in new homes a windowsill height to allow for seated viewing outside incurred no additional cost as this was considered “a standard sill height” and did not involve changing the window size (Houses = 1.28; Apartments = 1.45; Townhouses = 1.45). The change possibly “may have design/planning implications”, meaning it would benefit from inclusion at the design stage, but otherwise would involve “little or no change” from a “product, material or administrative perspective”.

28. Slip-resistant flooring

The nominating of slip-resistant flooring was thought to have of little or no cost implication to new builds (Houses = 1.84; Apartments = 1.84; Townhouses = 1.84). Respondents stated that slip-resistant flooring was already a “standard item” and therefore had no or low costs associated with it. One comment was that flooring manufacturers were already taking these requirements into account by offering a range of non-slip products.

Discussion

Many design elements were not difficult and virtually cost-neutral, including width of pathway to entrance, entrance door width, transition height for different floor surfaces, toilet on ground floor, toilet located in corner of combined bathroom, removable shower screen, shower size, laundry space, height of switches, height of power outlets, height of door handles, door hardware, tap hardware, windowsill height and slip-resistant flooring. Architects and access consultants also regularly pointed out that some of the accessible design elements were already standard industry practice. Providing a consistent, convenient height for the installation of door handles, switches and power outlets was seen as "standard" by some. A few design features were rated as being more difficult or costly, including provision for a future stair-climber or lift, internal stairways with no winders, closet toilet walls with adequate space and a step-free pathway to the entrance of homes.

"incorporating accessible design features early in new builds is the way to ensure cost effectiveness"

Across all the features, a frequent theme was noted regarding the importance of including the accessible feature at the design stage. This extended from those features considered not difficult and of little or no additional cost, to the potential to mitigate increased cost and/or difficulty in features where these were considered more costly. Respondents repeatedly stated that incorporating accessible design features early in new builds is the way to ensure cost effectiveness.

Respondents also reported that inclusion of more features as standard would reduce their costs over time. Some were noted as already being standard practice (including the width of paths, size of the entrance door, and the heights of light switches). It was also recognised that if accessible design features became a required or expected feature in all new homes, builders would quickly become more skilled with providing them, leading to a further saving in time and money. Increasing standardisation of size (e.g. doors) will result in fewer product options and reduce costs and errors in construction. Finally, respondents commented on the fact that increased market pressure could contribute to market expectations and increased development of further accessible solutions and products.

While generally there was consistency in the ratings of cost and difficulty of incorporating design features into new properties, there were some design elements where there was some variation in responses. This may be due to the provision of options within the response. Where this occurred (for example, regarding kitchen space, or closet toilet walls with adequate space) the qualitative responses indicated that the feature could be achieved with low cost and difficulty should the option with the smaller spatial requirements be implemented, while adopting the option with a larger spatial requirement would increase the impact of cost and/or difficulty.

Architects and access consultants noted differences in the cost and difficulty ratings of the design elements, depending on the dwelling type. Houses were generally considered to have the most scope to incorporate many accessible features with little or no difficulty and cost. For example, achieving step-free access from the boundary was seen to present design challenges and varied opinions on cost implications across a range of typologies generally related to the site dimensions and topography. The relative cost of design solutions per dwelling were considered proportionally less when spread across multiple apartments when compared with townhouses and houses.

The existing requirements for apartments to comply with the *Access to Premises Standards* (Commonwealth of Australia, 2010) results in a step-free pathway from the property boundary and a step-free entrance to the dwelling being rated as lower cost and difficulty.

This points to the importance of legislation in achieving acceptance and adoption of building features that enhance access for all the community. Assumptions regarding siting and design constraints for townhouses may have resulted in some features being seen as more difficult and/or costly to incorporate in this dwelling type. These include step-free access from the property boundary, the dwelling entrance, a shower on the ground floor and kitchen space.

Towards a design-led approach

The cost estimates to include accessible features in all new dwellings generally overstate the amount of "extra space" required because the costs are not based on a design-led approach. The cost estimates to date seem to focus on each component and sub-component as an extra cost and do not account for the degree to which accessible features are already included in some new homes (CIE, 2020; DCWC, 2020). For example, a recent audit of new houses found that most features are already being incorporated in many new homes (Winkler et al., 2020). Unfortunately, the accessible features generally did not align in the 1 home to make the dwelling suitable for someone with a mobility limitation or hoping to age in place.

"exemptions to accessibility standards could mitigate issues arising in the minority of new homes with site-specific challenges"

The qualitative findings of this survey indicate that a design-led approach to incorporating minimum accessibility standards would reduce the cost impact and improve the overall design of Australian housing for all occupants. Through a design-led approach there is space to accommodate minimum accessibility standards with minimal extra cost or impact on amenity. For instance, in a design-led approach there is ample scope for overlapping circulation from showers, basins and toilets, as well as room to modify the shape of bathrooms without increasing the overall space allocated to bathrooms. A design-led approach also has enormous potential to reduce the need for additional space by minimising corridors in smaller dwellings to create more spacious open plan homes. Thinking about a space holistically can address both construction costs and space costs. Rather than treating each accessible feature as an extra to be included, most accessible features can be designed in, or are indeed already being provided.

Australia has some of the biggest homes in the world. The average household has 2.6 people and there is an average of 3.1 bedrooms in every Australian home. The vast majority of homes in Australia are either stand-alone houses (71%) or 1-storey townhouses (7%) (ABS 2016). This means that the implementation of minimum accessibility standards through a design-led approach is highly feasible. And while this survey noted challenges to including accessible features in townhouses, these generally arise in the minority of townhouses that are more than 1 storey, and where the garage takes up most of the ground floor. This means that the implementation of minimum accessibility standards is likely to be challenging in less than 15% of dwellings.

Furthermore, architects and access consultants cited concerns with some particular types of sites that would add to the cost and difficulty of including some accessible features. However, targeted exemptions to accessibility standards could mitigate issues arising in the minority of new homes with site-specific challenges, including complex topography or compact bathrooms in smaller dwellings. A design-led approach would consider a space holistically and minimise both the construction cost and the space cost. The inclusion of minimum accessible features is feasible in the vast majority of new Australian homes.

Conclusion

Many of the homes built today will still be in use in 50 or more years. Australia needs high quality housing that is flexible and adaptable to the changing needs of our ageing population rather than housing that will become functionally obsolete. While the upfront cost is important, the useful lifespan of a dwelling is also an important economic consideration. This study explored the cost and difficulty of including accessible design features in all new homes in Australia, to assess their inclusion as mandatory accessibility standards in the 2022 NCC. By seeking the expert opinions of architects and access consultants, it provides an evidence base to help inform decision-makers and the ABCB on the costs and difficulty of incorporating accessible features into all new homes.

The study found that 12 of the 28 accessible features are easy and cheap (or cost-neutral) to incorporate across all new houses, apartments and townhouses. Many of these are common-sense design features that are already quickly becoming industry standard, including the height of power outlets and slip-resistant flooring. Architects and access consultants repeatedly stated that incorporating accessible design features early in new builds is the way to ensure cost effectiveness. This indicates that a design-led approach to incorporating minimum accessibility standards would reduce the cost impact and improve the overall design of new homes in Australia. Minimum accessibility standards are likely to incur a one-off cost rather than an ongoing cost as the building sector adapts to building houses that are more thoughtfully designed and future-proof. Furthermore, features that are more costly or difficult to incorporate in 1 type of dwelling may be inexpensive and simple in another.

"Minimum accessibility standards are likely to incur a one-off cost rather than ongoing costs"

Australian homes are some of the biggest in the world, and the majority of these are stand-alone houses. Respondents to this survey noted the challenge of including accessible features in more complex sites, such as townhouses with 2 or more storeys. However, these more challenging sites are only a small proportion of all Australian homes, which means that implementing accessibility standards through a design-led approach is very achievable.

The findings of this study suggest that many accessible design features currently under consideration by the ABCB would not be difficult or costly to include in all new homes in Australia. These features could become mandatory minimum accessibility standards without causing any great inconvenience or cost to builders or homeowners. Given the number of Australians requiring accessible housing is rising due to an ageing population, incorporating these changes now will have far-reaching benefits. Future research can draw on the findings of this study and further explore the impact of these design elements on the lives of people with mobility limitations, in order to determine the most essential housing design features. This would ensure that the changes being considered will directly improve the quality of lives of people with mobility limitations.

This study has provided a solid evidence base on the cost and difficulty of incorporating accessible design features as mandatory standards in all future Australian dwellings. Standardising accessible housing design features will not only improve their cost-efficiency over time, it will also significantly improve the freedom, social inclusion, and overall wellbeing of Australians living with mobility limitations, now and in the future.

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Appendix

Table 4. Average (mean) difficulty and cost of incorporating design features into new dwellings (1 = not difficult/virtually cost neutral; 4 = very difficult/high cost)

		House		Apartment		Townhouse	
	Design feature	Difficulty	Cost	Difficulty	Cost	Difficulty	Cost
1.	Step-free pathway to entrance	1.78	1.95	1.48	1.64	2.00	2.10
2.	Width of pathway to entrance	1.22	1.45	1.22	1.36	1.26	1.41
3.	Step-free entrance to residence	1.74	1.86	1.35	1.45	1.96	1.86
4.	Entrance door width	1.13	1.23	1.17	1.23	1.17	1.23
5.	Transition height for different floor surfaces	1.45	1.71	1.41	1.62	1.45	1.71
6.	Internal door and corridor widths	1.43	1.80	1.57	1.75	1.71	1.90
7.	Toilet on ground floor	1.48	1.50	1.38	1.45	1.82	1.75
8.	Space in front of toilet	1.67	1.75	2.10	2.25	2.19	2.05
9.	Closet toilet walls	1.70	1.84	1.90	2.16	2.00	2.11
10.	Toilet in bathroom located in corner	1.29	1.35	1.33	1.40	1.41	1.35
11.	Shower on ground floor	1.48	1.50	1.48	1.40	2.29	2.35
12.	Removable shower screen	1.48	1.50	1.52	1.50	1.52	1.50
13.	Step-free shower entry	1.52	1.65	1.76	1.95	1.71	1.80
14.	Shower size	1.19	1.15	1.29	1.25	1.24	1.20
15.	Space adjacent to shower	1.48	1.55	1.95	2.01	1.90	2.00
16.	Reinforcement of bathroom and toilet walls	1.33	2.00	1.38	2.00	1.38	2.00
17.	Internal stairways - no winders	1.60	1.84	1.70	2.00	2.00	2.16
18.	Provision for future stair-climber or lift	2.15	2.50	2.00	1.59	2.32	2.72
19.	Kitchen space	1.65	1.79	2.00	2.00	2.32	1.95
20.	Laundry space	1.00	1.05	1.05	1.10	1.00	1.05
21.	Ground (or entry level) bedroom space	1.57	1.60	1.67	1.65	2.14	2.15
22.	Height of switches	1.00	1.00	1.00	1.00	1.00	1.00
23.	Height of power outlets	1.00	1.00	1.00	1.00	1.00	1.00
24.	Height of door handles	1.05	1.00	1.00	1.00	1.00	1.00
25.	Door hardware	1.00	1.00	1.00	1.00	1.00	1.00
26.	Tap hardware	1.00	1.11	1.00	1.11	1.00	1.11
27.	Windowsill height	1.15	1.11	1.25	1.16	1.25	1.16
28.	Slip-resistant flooring	1.25	1.47	1.25	1.47	1.25	1.47

Table 5. Descriptive characteristics regarding the difficulty of incorporating each design feature into houses, apartments, and townhouses (1 = not difficult to 4 = very difficult)

	House				Apartment				Townhouse			
Design feature	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**
Step-free pathway to entrance	1.78	0.80	2	1	1.48	0.67	1	1	2.00	0.90	2	3
Width of pathway to entrance	1.22	0.42	1	1	1.22	0.42	1	1	1.26	0.45	1	1
Step-free entrance to residence	1.74	0.86	2	1	1.35	0.65	1	1	1.96	0.98	2	1
Entrance door width	1.13	0.34	1	1	1.17	0.39	1	1	1.17	0.39	1	1
Transition height for different floor surfaces	1.45	0.74	1	1	1.41	0.73	1	1	1.45	0.74	1	1
Internal door and corridor widths	1.43	0.68	1	1	1.57	0.75	1	1	1.71	0.78	2	1
Toilet on ground floor	1.48	0.68	1	1	1.38	0.67	1	1	1.82	0.80	2	1
Space in front of toilet	1.67	0.80	2	1	2.10	0.77	2	2	2.19	0.93	2	3
Closet toilet walls	1.70	0.86	1.5	1	1.90	0.85	2	1	2.00	0.97	2	1
Toilet in bathroom located in corner	1.29	0.56	1	1	1.33	0.66	1	1	1.41	0.73	1	1
Shower on ground floor	1.48	0.60	1	1	1.48	0.68	1	1	2.29	0.85	3	3
Removable shower screen	1.48	0.81	1	1	1.52	0.81	1	1	1.52	0.81	1	1
Step-free shower entry	1.52	0.68	1	1	1.76	0.83	2	1	1.71	0.78	2	1
Shower size	1.19	0.51	1	1	1.29	0.56	1	1	1.24	0.54	1	1
Space adjacent to shower	1.48	0.68	1	1	1.95	0.80	2	2	1.90	0.77	2	2
Reinforcement of bathroom and toilet walls	1.33	0.58	1	1	1.38	0.59	1	1	1.38	0.59	1	1
Internal stairways - no winders	1.60	0.75	1	1	1.70	0.86	1	1	2.00	0.92	2	1, 3
Provision for future stair-climber or lift	2.15	0.93	2	3	2.00	1.08	2	1	2.32	1.06	3	3

	House				Apartment				Townhouse			
Design feature	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**
Kitchen space	1.65	0.67	2	1, 2	2.00	1.08	2	1	2.32	1.06	3	1
Laundry space	1.00	0	1	1	1.05	0.22	1	1	1.00	0	1	1
Ground (or entry level) bedroom space	1.57	0.75	1	1	1.67	0.86	1	1	2.14	0.96	3	3
Height of switches	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Height of power outlets	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Height of door handles	1.05	0.22	1	1	1.00	0	1	1	1.00	0	1	1
Door hardware	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Tap hardware	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Windowsill height	1.15	0.37	1	1	1.25	0.55	1	1	1.25	0.55	1	1
Slip-resistant flooring	1.25	0.55	1	1	1.25	0.55	1	1	1.25	0.55	1	1

Table 6. Average responses regarding the difficulty of implementing each design feature in houses, apartments and townhouses presented in rank order of least difficult to most difficult

Houses				Apartment				Townhouses			
Rank	**Design feature**	**Mean**	**SD**	**Rank**	**Design feature**	**Mean**	**SD**	**Rank**	**Design feature**	**Mean**	**SD**
1	Height of switches	1	0	1	Height of switches	1	0	1	Height of switches	1	0
1	Height of power outlets	1	0	1	Height of power outlets	1	0	1	Height of power outlets	1	0
1	Door hardware	1	0	1	Door hardware	1	0	1	Door hardware	1	0
1	Tap hardware	1	0	1	Tap hardware	1	0	1	Tap hardware	1	0
1	Laundry space	1	0	1	Height of door handles	1	0	1	Laundry space	1	0
2	Height of door handles	1.05	0.22	2	Laundry space	1.05	0.22	1	Height of door handles	1	0
3	Entrance door width	1.13	0.34	3	Entrance door width	1.17	0.39	2	Entrance door width	1.17	0.39
4	Windowsill height	1.15	0.37	4	Width of pathway to entrance	1.22	0.42	3	Shower size	1.24	0.54
5	Shower size	1.19	0.51	5	Windowsill height	1.25	0.55	4	Windowsill height	1.25	0.55
6	Width of pathway to entrance	1.22	0.42	5	Slip-resistant flooring	1.25	0.55	4	Slip-resistant flooring	1.25	0.55
7	Slip-resistant flooring	1.25	0.55	6	Shower size	1.29	0.56	5	Width of pathway to entrance	1.26	0.45
8	Toilet in bathroom located in corner	1.29	0.56	7	Toilet in bathroom located in corner	1.33	0.66	6	Reinforcement of bathroom and toilet walls	1.38	0.59
9	Reinforcement of bathroom and toilet walls	1.33	0.58	8	Step-free entrance to residence	1.35	0.65	7	Toilet in bathroom located in corner	1.41	0.73
10	Internal doors and corridor widths	1.43	0.68	9	Toilet on ground floor	1.38	0.67	8	Transition height for different floor surfaces	1.45	0.74
11	Transition height for different floor surfaces	1.45	0.74	9	Reinforcement of bathroom and toilet walls	1.38	0.59	9	Removable shower screen	1.52	0.81
12	Toilet on ground floor	1.48	0.68	10	Transition height for different floor surfaces	1.41	0.73	10	Internal door and corridor widths	1.71	0.78
13	Shower on ground floor	1.48	0.6	11	Step-free pathway to entrance	1.48	0.67	10	Step-free shower entry	1.71	0.78

Houses				Apartment				Townhouses			
Rank	**Design feature**	**Mean**	**SD**	**Rank**	**Design feature**	**Mean**	**SD**	**Rank**	**Design feature**	**Mean**	**SD**
14	Removable shower screen	1.48	0.81	11	Shower on ground floor	1.48	0.68	11	Toilet on ground floor	1.82	0.8
14	Space adjacent to shower	1.48	0.68	12	Removable shower screen	1.52	0.81	12	Space adjacent to shower	1.9	0.77
15	Step-free shower entry	1.52	0.68	13	Internal door and corridor widths	1.57	0.75	13	Step-free entrance to residence	1.96	0.98
16	Ground (or entry level) bedroom space	1.57	0.75	14	Ground (or entry level) bedroom space	1.67	0.86	14	Step-free pathway to entrance	2	0.9
17	Internal stairways - no winders	1.6	0.75	15	Internal stairways - no winders	1.7	0.86	14	Internal stairways - no winders	2	0.92
18	Kitchen space	1.65	0.67	16	Step-free shower entry	1.76	0.83	14	Closet toilet walls	2	0.97
19	Space in front of toilet	1.67	0.8	17	Closet toilet walls	1.9	0.85	15	Ground (or entry level) bedroom space	2.14	0.96
20	Closet toilet walls	1.7	0.86	18	Space adjacent to shower	1.95	0.8	16	Space in front of toilet	2.19	0.93
21	Step-free entrance to residence	1.74	0.86	19	Provision for future stair-climber or lift	2	1.08	17	Shower on ground floor	2.29	0.85
22	Step-free pathway to entrance	1.78	0.8	19	Kitchen space	2	1.08	18	Provision for future stair-climber or lift	2.32	1.06
23	Provision for future stair-climber or lift	2.15	0.93	20	Space in front of toilet	2.1	0.77	18	Kitchen space	2.32	1.06

Table 7. Descriptive characteristics regarding the cost of incorporating each design feature into houses, apartments, and townhouses (1 = virtually cost neutral to 4 = high cost)

	House				Apartment				Townhouses			
Design Feature	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**
Step-free pathway to entrance	1.95	0.86	2	1	1.64	0.79	1.5	1	2.10	0.89	2	3
Width of pathway to entrance	1.45	0.67	1	1	1.36	0.79	1	1	1.41	0.67	1	1
Step-free entrance to residence	1.86	0.71	2	2	1.45	0.80	1	1	1.86	0.83	2	1
Entrance door width	1.23	0.43	1	1	1.23	0.43	1	1	1.23	0.43	1	1
Transition height for different floor surfaces	1.71	0.85	2	1	1.62	0.86	1	1	1.71	0.85	2	1
Internal door and corridor widths	1.80	1.01	1.5	1	1.75	0.97	1.5	1	1.90	0.97	2	1,2
Toilet on ground floor	1.50	0.69	1	1	1.45	0.69	1	1	1.75	0.79	2	1
Space in front of toilet	1.75	0.85	2	1	2.25	0.79	2	3	2.05	0.89	2	2
Closet toilet walls	1.84	0.96	2	1	2.16	1.01	2	3	2.11	0.99	2	1,3
Toilet in bathroom located in corner	1.35	0.67	1	1	1.40	0.75	1	1	1.35	0.67	1	1
Shower on ground floor	1.50	0.76	1	1	1.40	0.68	1	1	2.35	0.93	3	3
Removable shower screen	1.50	0.89	1	1	1.50	0.89	1	1	1.50	0.89	1	1
Step-free shower entry	1.65	0.67	2	1,2	1.95	0.83	2	1,2	1.80	0.83	2	1
Shower size	1.15	0.37	1	1	1.25	0.44	1	1	1.20	0.41	1	1
Space adjacent to shower	1.55	0.60	1.5	1	2.01	0.83	2	2	2.00	0.73	2	2
Reinforcement of bathroom and toilet walls	2.00	0.32	2	2	2.00	0.32	2	2	2.00	0.32	2	2
Internal stairways - no winders	1.84	0.76	2	2	2.00	0.94	2	1	2.16	0.90	2	3
Provision for future stair-climber or lift	2.50	0.71	3	3	1.59	0.94	3	3	2.72	0.57	3	3
Kitchen space	1.79	0.71	2	2	2.00	0.88	2	2	1.95	0.78	2	2
Laundry space	1.05	0.22	1	1	1.10	0.31	1	1	1.05	0.22	1	1
Ground (or entry level) bedroom space	1.60	0.82	1	1	1.65	0.99	1	1	2.15	1.09	2	1
Height of switches	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1

	House				Apartment				Townhouses			
Design Feature	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**	**Mean**	**SD**	**Median**	**Mode**
Height of power outlets	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Height of door handles	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Door hardware	1.00	0	1	1	1.00	0	1	1	1.00	0	1	1
Tap hardware	1.11	0.32	1	1	1.11	0.32	1	1	1.11	0.32	1	1
Windowsill height	1.11	0.32	1	1	1.16	0.37	1	1	1.16	0.37	1	1
Slip-resistant flooring	1.47	0.61	1	1	1.47	0.61	1	1	1.47	0.61	1	1

Table 8. Average responses regarding the cost of implementing each design feature in houses, apartments and townhouses presented in rank order of least expensive to most expensive

Houses				Apartment				Townhouses			
Rank	**Design Feature**	**Mean**	**SD**	**Rank**	**Design Feature**	**Mean**	**SD**	**Rank**	**Design Feature**	**Mean**	**SD**
1	Height of switches	1	0	1	Height of switches	1	0	1	Height of switches	1	0
1	Height of power outlets	1	0	1	Height of power outlets	1	0	1	Height of power outlets	1	0
1	Height of door handles	1	0	1	Height of door handles	1	0	1	Height of door handles	1	0
1	Door hardware	1	0	1	Door hardware	1	0	1	Door hardware	1	0
2	Laundry space	1.05	0.22	2	Laundry space	1.1	0.31	2	Laundry space	1.05	0.22
3	Tap hardware	1.11	0.32	2	Tap hardware	1.11	0.32	3	Tap hardware	1.11	0.32
3	Windowsill height	1.11	0.32	3	Windowsill height	1.16	0.37	4	Windowsill height	1.16	0.37
4	Shower size	1.15	0.37	4	Entrance door width	1.23	0.43	5	Shower size	1.2	0.41
5	Entrance door width	1.23	0.43	5	Shower size	1.25	0.44	6	Entrance door width	1.23	0.43
6	Toilet in bathroom located in corner	1.35	0.67	6	Width of pathway to entrance	1.36	0.79	7	Toilet in bathroom located in corner	1.35	0.67
7	Width of pathway to entrance	1.45	0.67	7	Toilet in bathroom located in corner	1.4	0.75	8	Width of pathway to entrance	1.41	0.67
8	Slip-resistant flooring	1.47	0.61	7	Shower on ground floor	1.4	0.68	9	Slip-resistant flooring	1.47	0.61
9	Toilet on ground floor	1.5	0.69	8	Step-free entrance to residence	1.45	0.8	10	Removable shower screen	1.5	0.89
9	Shower on ground floor	1.5	0.76	8	Toilet on ground floor	1.45	0.69	11	Transition height for different floor surfaces	1.71	0.85

Houses				Apartment				Townhouses			
Rank	**Design Feature**	**Mean**	**SD**	**Rank**	**Design Feature**	**Mean**	**SD**	**Rank**	**Design Feature**	**Mean**	**SD**
9	Removable shower screen	1.5	0.89	9	Slip-resistant flooring	1.47	0.61	12	Toilet on ground floor	1.75	0.79
10	Space adjacent to shower	1.55	0.6	10	Removable shower screen	1.5	0.89	13	Step-free shower entry	1.8	0.83
11	Ground (or entry level) bedroom space	1.6	0.82	11	Provision for future stair-climber or lift	1.59	0.94	14	Step-free entrance to residence	1.86	0.83
12	Step-free shower entry	1.65	0.67	12	Transition height for different floor surfaces	1.62	0.86	15	Internal door and corridor widths	1.9	0.97
13	Transition height for different floor surfaces	1.71	0.85	13	Step-free pathway to entrance	1.64	0.79	16	Kitchen space	1.95	0.78
14	Space in front of toilet	1.75	0.85	14	Ground (or entry level) bedroom space	1.65	0.99	17	Space adjacent to shower	2	0.73
15	Kitchen space	1.79	0.71	15	Internal door and corridor width	1.75	0.97	17	Reinforcement of bathroom and toilet walls	2	0.32
16	Internal door and corridor widths	1.8	1.01	16	Step-free shower entry	1.95	0.83	18	Space in front of toilet	2.05	0.89
17	Closet toilet walls	1.84	0.96	17	Reinforcement of bathroom and toilet walls	2	0.32	19	Step-free pathway to entrance	2.1	0.89
18	Internal stairways - no winders	1.84	0.76	18	Internal stairways - no winders	2	0.94	20	Closet toilet walls	2.11	0.99
19	Step-free entrance to residence	1.86	0.71	18	Kitchen space	2	0.88	21	Ground (or entry level) bedroom space	2.15	1.09
20	Step-free pathway to entrance	1.95	0.86	20	Space adjacent to shower	2.01	0.83	22	Internal stairways - no winders	2.16	0.9

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