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A priority-based 'design for all' approach to guide home designers for independent living

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The aim is to provide a priority-based 'design for all' approach list that can be used as a guide in the architectural design process for independent living of the home users. It is important to prioritize 'design for all' factors and their items as well as the significant differences among adults, elderly and adults with physical disability and visual impairments for the design of homes. A survey was conducted with 161 participants, including adults, elderly and adults with physical disabilities and visual impairments. The results of a factor analysis test identified six high-loaded (adequate illumination level, ease of use in kitchen, adequate space for approach and use, adequate contrast between essential information and its surroundings, ease of use in accessories and functional vertical circulation) and three low-loaded factors (provision of privacy and safety in bathroom, safety of floors and accessibility to all spaces). Multiple comparison tests were done in order to determine the group differences in each prioritized factor for diverse users. Furthermore, a priority-based list with the characteristic features of the 'design for all' approach for independent living is developed as a guide for home designers.

Keywords: aging; design for all; physically disabled; elderly; universal design; visual impairment

Introduction

The increase in life expectancy, the resulting growth of the elderly population (IASA 2002; United Nations 2007) and preference to age in familiar environments (Demirkan 2007) are some of the driving forces for designers to consider the 'design for all' approach. This approach incorporates the needs and wishes of all individuals to the greatest possible extent, regardless of their abilities while using their environments. In the past years, there has been a tendency to consider groups with special needs in the design process. This was mostly achieved with a specialized and distinct design solution incorporated into the regular one (Demirkan 2007). According to the approach, this leads to a segregation of groups within the population. Since the entire 'design for all' requirements cannot be equally satisfied, a designer must determine the relative importance and implementation order of each requirement. Prioritization of requirements is needed to guide designers for diverse users in home designs.

The 'design for all' approach has also been extensively studied under the concept of universal design (often referenced in Europe as 'inclusive design'). Universal design is defined as 'an approach to creating environments and products that are usable by all people to the greatest extent possible' (Mace, Hardie, and Plaice 1991, 156). It has seven principles as seen in Table 1. Story, Mueller, and Mace (1998) stated that the root of universal design was deep and strong throughout the twentieth century due to the demographic, legislative, economic and social changes among

older adults and people with disabilities. Trost (2005) stated that universal design suggests a comprehensive philosophy, whereas 'design for all' relates to practical applications. Both of them suggest a holistic approach for all users that does not include individuals with disabilities as a specialized group. The universal design concept lacks established criteria for determining the requirements of a usable environment by all people to the greatest extent possible. Aslaksen et al. (1997) claimed that there is a gap between the ideal of 'usable by all people' and the actual solutions. 'Design for all' emphasizes that the demands of all users should be valued on equal terms and the ones that should be excluded should be made consciously. The challenge of the approach also started many discussions on the issue of a design that is 'usable by all people' (Bevan 1995). Consequently, many international standards were published to support the usability of products (Bevan 2001).

Considering the importance of all diverse populations in the design process, Steinfeld and Maisel (2012) improved the definition of universal design as 'a process that enables and empowers a diverse population by improving human performance, health and wellness and social participation' (29). They also pointed out that universal design should not focus only on the physical environment but also on the quality of life technologies and delivery of services. Furthermore, Steinfeld and Maisel (2012) proposed the following eight goals of universal design: body fit, comfort, awareness, understanding, wellness, social integration,

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Table 1. The principles of universal design (The Center for Universal Design 1997).

Principles	Description
1. Equitable use	The design is useful and marketable to people with diverse abilities
2. Flexibility in use	The design accommodates a wide range of individual preferences and abilities
3. Simple and intuitive use	Use of the design is easy to understand, regardless of the user's experience, knowledge, language skills or current concentration level
4. Perceptible information	The design communicates necessary information effectively to the user, regardless of ambient conditions or the user's sensory abilities
5. Tolerance for error	The design minimizes hazards and the adverse consequences of accidental or unintended actions
6. Low physical effort	The design can be used efficiently and comfortably, and with a minimum of fatigue
7. Size and space for approach and use	Appropriate size and space is provided for approach, reach, manipulation, and use, regardless of the user's body size, posture or mobility

personalization and appropriateness. They stated that these goals correspond to specific bodies of knowledge that are compatible with the seven principles of universal design (see Table 1). These goals clarify the outcomes of the design process as the practice of the design profession and integrate them with the relevant knowledge basis. In addition, Steinfeld and Maisel (2012) added that it is clear that there is no general rule in design practice that could address all the eight goals of universal design.

Diversified user groups such as individuals with disabilities and elderly should be considered as well as individuals with average abilities in home designs. So that, the provided solutions for design process could include all users in a holistic perspective. There is a broad body of written documents that refers to elderly and individuals with disabilities. These include the standards, references and norms that guide the design process (ANSI 1986; BSI 1979; Fair Housing Act Design Manual 1996 and many others). These are of limited use to many designers, since they do not prioritize the user's needs, capabilities and expectations (Afacan and Demirkan 2010).

Also, there is research conducted by health professionals that focuses on the features of a physical environment to evaluate the built environment for diverse users. Stark et al. (2007) developed the Community Health Environment Checklist to measure the items of the physical environment that are crucial for individuals with mobility aids. This checklist aimed to guide the health professionals, community health planners and policy-makers in evaluating either part of a home, such as a kitchen or bathroom, or an activity that can be conducted at various parts of a home. Murphy, Gretebeck, and Alexander (2007) focused on the bathing activities of adult individuals. Stineman, Ross, and Maislin (2007) studied the activities of daily living within the context of biological, psychological, socio-economic and environmental issues.

'Design for all' in homes

Research related to 'design for all' in homes flourished more in the product field (Beecher and Paquet 2005; Demirbilek

and Demirkan 2004; Demirbilek, Demirkan, and Alyanak 2000; Demirkan 2007) than in the built environment (Mace et al. 1991). The literature sources for the built environment mostly provide the requirements of elderly individuals for a safe and functional environment (Afacan and Demirkan 2010; Demirbilek and Demirkan 1998, 2000; Sagdic and Demirkan 2000). Also, some sources have developed a list of characteristic features of homes in the form of checklists as a guide for designers (Mace 1998). Iwarsson and Slaug (2001) developed the Housing Enabler instrument to assess both the individual's functional limitations (15 items) and the demands of the environment (188 items). For many years, the occupational therapists used the original version of the instrument in various countries and tested its reliability and validity. Later, Carlsson et al. (2009) utilized the reduced version of the Housing Enabler with 61 items for assessing accessibility to houses. Recently, Iwarsson, Slaug, and Fange (2012) recommended that other professional groups such as architects and real estate staff should use the Housing Enabler.

Also, Ostroff and Weisman (2004) developed the initial survey as a tool for evaluating existing buildings within the context of universal design. They adapted the titles for universal design principles (see Table 1) and combined some of the principles. Principles 3 and 4 were combined into one title and named as 'clarity'. Also, principles 6 and 7 were combined into one title as 'comfort'. The brief titles they provided were as follows: 'inclusiveness' for principle 1, 'choice' for principle 2 and 'safety' for principle 5. Their study was designed for evaluating the existing public buildings.

The aging of many societies and the increased number of people with disabilities provide an urgency to adapt design issues and standards to the 'design for all' approach as policy and practice to satisfy the needs of individuals. Imrie (2012) stated that today universal design supports market mechanisms as a primary means to design accessible environments although it was used as the basis for rehabilitation before. Extending beyond disability and aging population, designers should examine personal circumstances and temporary health problems, as having a back pain or carrying

a rolling luggage, coffee or child changes the way one interacts with the environment. Since all 'design for all' requirements cannot be equally satisfied, a designer must determine the relative importance of each requirement. For a designer it is hard to prioritize 'design for all' requirements. Past research does not provide information on prioritizing (Afacan and Demirkan 2010). The holistic perspective embedded in the approach should be systematically and consistently developed during the design process and prioritizing would provide a better understanding of the issue. Prioritizing the design requirements of 'design for all' would guide the design process and provide criteria for new usable environments.

The research question of this study is how to prioritize 'design for all' factors and their items for the design of homes. Also, the study aims to see if there is a significant difference among adults, elderly and adults with physical disability and visual impairments in terms of the approach. This study is important in prioritizing 'design for all' factors among diverse user groups that would both ensure the inclusiveness of different needs and quicken the design process. Also, a priority-based list with the characteristic features of the 'design for all' approach for independent living is developed, which is expected to evolve into a guide in the decision-making process of designers. The decision-making process of designers still relies heavily on subjective and empirical priority assessments (Afacan and Demirkan 2010). In order to guide designers in the decision-making process, this study aims to propose a priority list that is based on a survey of diverse user groups.

Method

The aim of this study is to determine and prioritize the issues that are important for diverse users within the context of 'design for all'. In order to achieve this, a set of survey questions (referred to as items in the text) was developed. Diverse users indicate users with different capabilities and abilities. The survey was conducted with four types of users: individuals with physical disabilities, individuals with visual impairments, elderly and adults. The participants of both the preliminary and the final survey were all fully informed about the aims and scope of the survey. All participants were volunteers and they gave their consent to be included in the study. Human subjects research was also approved for this study by the related university department. The results of the survey were statistically tested to obtain a set of prioritized items for all four types of users that are essential in homes designed for all.

The preliminary survey

The initial challenge was to determine and refine the items to be evaluated in the survey. Two experts in universal design, who are members of academia teaching and have been researching the subject at least for eight years, formulated

common shortcomings of homes in terms of 'design for all' into items of the survey using their field experience and the literature. To this initial set of items, statements proposing a design solution for universal design in homes from universal design exemplars were added (The Center for Universal Design 2000).

The survey responses for each item were designed on a five-point Likert scale from 'least important' to 'most important'. The 97 items of the survey were translated into Turkish. Later, two bilingual experts who are native speakers translated it back to English in order to check the items with their originals. Few items were revised in Turkish translation according to their suggestions.

A pilot study was conducted with 12 participants to refine the items. Each group was composed of three participants. Two of the participants with physical disabilities were wheelchair users, while one of them was using a quad cane. They were two men and one woman. The participants with visual impairments were all women. The elderly (age more than 65) participants were one woman and two men. The adult (age between 18 and 64) participants were two women and one man. The survey took about 60 minutes to answer and all participants answered the items in one session.

The preliminary survey was used to refine the survey questions and produce the final survey. The first step in simplifying the survey was to find and exclude the items that were not depicting the actual variability of the responses. Item response means were evaluated to determine whether a large percentage of participant responses created a floor (i.e. very low mean value) or ceiling effect (i.e. very high mean value). No question was eliminated, since none of them created a floor or ceiling effect. As Tabachnick and Fidell (1996) stated when the individual scores are at one or both of the extreme ends of the scale the actual variability in responses may not be captured. Also, the items with responses greater than 20% as 'not applicable' were also excluded. After these exclusions, the initial 97 items suggested for the survey were refined to 77 items for the final survey.

Final survey

Participants of the final survey

A quota sampling method is used in determining the user groups similar to their distribution in the population. Individuals with physical disabilities were selected by random sampling from the existing database of the Federation of the Physically Handicapped of Turkey and Turkish Handicap Association. Individuals with visual impairments were selected by random sampling from the database of the Federation of the Blind of Turkey. The inclusion criterion for individuals with physical disabilities and individuals with visual impairments was that they had to be registered with any of the above federations or associations, the exclusion

Table 2. Demographics of participants ($n = 161$).

Sample characteristics	Visually impaired	Physically disabled	Adult	Elderly	Total
Gender					
Female	16	13	38	25	92
Male	15	22	22	10	69
Age					
Mean	35.6	42.6	37.2	74.7	
SD	17.14	11.58	37.20	74.69	
Range	18–82	24–78	21–61	65–91	
Total	31	35	60	35	161

criterion was having multiple or mental disabilities. The inclusion criterion for adult and elderly individuals was age (to be above or below 65 years of age). The exclusion criterion was having any physical, sensory or mental disability. Participation was on voluntary basis.

A total of 161 individuals participated in the survey, including 31 individuals with visual impairments, 35 individuals with physical disabilities, 60 adults and 35 elderly. There were 69 (43%) males and 92 (57%) females. The demographics of the participants are shown as the distribution of gender and age in Table 2.

The age range of individuals with visual impairments is between 18 and 82. A total of 17 of them are blind cane users, while the rest do not use any assisting device. Individuals with physical disabilities are between 24 and 78 of age. A total of 13 of them are wheelchair users, 10 of them use crutches, 9 of them use canes and 3 of them use no assisting devices. Adults are between 21 and 61 years of age. Elderly people are between 65 and 91 years of age.

The survey

The survey involved questions related to the demographic characteristics of the individuals such as age, gender, disability profile and assisting devices. The final survey had 77 items as seen in the Appendix. These items were grouped according to the space they are related to as the entrance of the main building, home entrance, bathroom, kitchen, bedroom, living room, circulation spaces and

elements/controls. The survey was taken individually with paper and pencil. One research assistant was present during the survey in case the participants would like to have assistance. The answers to the survey items were analysed with factor analysis to find out the importance ranking of the items by diverse participants with differing abilities. In this way, a list of priorities for homes designed for all was obtained.

Results and discussion

Related to the survey

The factor analysis test was used to group the related items under a factor and to order these items according to their importance. In this way, a list of prioritized factors and their items was obtained for the design of homes. Initially, a principal component analysis was conducted on the correlations of 77 items. The correlation matrix was inspected to determine if the strength of the correlation among the items was reliable for factor analysis; since no item was found below 0.30, all items of the survey were retained. The variances on the 19 factors were successively extracted with eigenvalues greater than 1. Eigenvalues indicate the amount of variance explained by each factor.

Among the 19 factors, 9 had at least 3 items and the rest had less; thus, these 9 factors were considered in this study. These nine factors accounted for the 47.83% of the variance as seen in Table 3. An orthogonal factor rotation was performed using the varimax with Kaiser normalization. According to Tabachnick and Fidell (1996), an item's pure measure of the factor increases with greater loading. Items that had relationships 50% and above with the factor component were thought to describe the factor and its related scale the best; thus those items would provide the best assessment for that particular scale.

The prioritized 'design for all' factors and the corresponding loadings of the items on these nine factors are shown in Table 4. The factors included only the items with 0.50 or more loading weights. The prioritized factors and their related items are listed from the most important to the relatively less important. In Table 4, each item is numbered with the relevant item number from the survey (see appendix) and its loading is included in parentheses.

Table 3. Summary of rotated factors.

Factor	Scale	Eigenvalue	Variance (%)	Cumulative (%)
1	Adequate illumination level in all spaces	19.96	7.18	7.18
2	Ease of use in kitchen	4.77	6.99	14.17
3	Adequate space for approach and use	3.64	6.97	21.14
4	Adequate contrast between essential information and its surroundings	3.42	5.67	26.81
5	Ease of use in accessories	3.11	4.92	31.73
6	Functional vertical circulation	2.50	4.40	36.13
7	Provision of privacy and safety in bathroom	2.21	4.24	40.37
8	Safety of floors in all spaces	1.86	3.83	44.20
9	Accessibility to all spaces	1.77	3.63	47.83

Table 4. Prioritized nine factors with the corresponding items.

Factor	Scale	Items with loadings $\geq 0.50^a$
1	Adequate illumination level in all spaces	34 Task lighting on top of counters in the kitchen (0.740) 65 Adequate illumination for circulation spaces (0.733) 22 Adequate illumination in the bathroom (0.691) 60 Adequate illumination on top of dining table (0.686) 27 Adequate illumination in the kitchen (0.681) 53 Closet interiors to be illuminated in the bedroom (0.678) 38 To have illumination inside kitchen cabinets (0.678)
2	Ease of use in kitchen	41 Cook-top to be used easily (0.841) 42 Oven to be used easily (0.778) 40 Refrigerator to be used easily (0.705) 45 All appliances to be provided with sufficient clear floor area in the kitchen (0.617)
3	Adequate space for approach and use	50 To move/manoeuvre easily in the bedroom (0.803) 49 Bedroom to provide adequate space for activities (0.757) 59 To move/manoeuvre easily in the living room (0.725) 58 To have adequate space in the living room (0.684) 73 All controls (light switches, window/door operators, electric outlets, etc.) to require little effort (0.533)
4	Adequate contrast between essential information and its surroundings	31 To have colour contrast between the sink and counter in the kitchen (0.810) 35 To have colour contrast between the counter and cabinets in the kitchen (0.789) 56 To have colour contrast between storage handles and storage doors in the bedroom (0.774) 17 To have colour contrast between the counter top and lavatory in the bathroom (0.733) 75 Light switches to have colour contrast with walls (0.719)
5	Ease of use in accessories	36 Cabinet handles to be used easily in the kitchen (0.617) 54 Closet handles to be used easily in the bedroom (0.564) 55 Closet handles to fit any hand in the bedroom (0.551) 33 Main counter to be used easily in the kitchen (0.543) 18 Faucets to be used easily in the bathroom (0.535)
6	Functional vertical circulation	71 Ramp slopes to be appropriate (0.814) 72 Ramps to have curbs or lips on the sides (0.772) 69 Staircases to be single flight, without a turn (0.654) 70 Handrails to be continuous and easily grasped (0.650)
7	Provision of privacy and safety in the bathroom	20 Toilet to be used without help (0.809) 13 Tub/shower to be used without help (0.796) 21 Toilets to be used with low effort and minimum fatigue (0.665)
8	Safety of floors in all spaces	44 Floor to be slip-resistant in the kitchen (0.893) 24 Floor to be slip-resistant in the bathroom (0.844) 64 Floor to be slip-resistant in circulation spaces (0.754)
9	Accessibility to all spaces	62 To have access to all rooms through circulation spaces (0.694) 63 Corridors to provide adequate space for passage and manoeuvring (0.644) 26 To move/manoeuvre easily in the kitchen (0.620)

^aItems could be followed with their numbers in the survey at the appendix, while the loadings are in parentheses.

Similar to architectural needs, the requirements of 'design for all' are complex, vast and multifaceted, so that a manageable prioritization process, which can handle increasing number of requirements, is considered of high importance (Ozkaya and Akin 2006). In literature, there is a study that applied quality function deployment techniques in determining the universal design requirements, but not as a prioritization process (Demirbilek and Demirkan 2004). Furthermore, Afacan and Demirkan (2010) applied a prioritization technique from engineering design to a universal

design case in the architectural design context. A universal kitchen design was chosen as a case study to demonstrate the application of the priority-based approach. This study proposed a CAD interface with a developed plug-in tool for universal kitchen design. The study was limited to kitchen design and did not classify the diverse user groups under each requirement. Thus, to be able to propose a suitable prioritization technique for home designs, this study selected the factor analysis technique, considering the behaviour of diverse user groups.

The results of the factor analysis grouped survey items into nine factors that were listed from the highest priority to the lowest. The statistical analyses showed that there was a significant difference among user groups in all factors. However, all the groups do not differ significantly from each other for each factor. Since all design requirements cannot be equally satisfied, a designer should be aware of the priority of the requirements as well as the category of the user groups that have no difference among them. This should guide the designers in improving their design solutions in order to have more usable and accessible environments for diverse users.

Related to the user groups

The factor analysis test helped to prioritize the 'design for all' factors and their items for independent living of the home users. The uncorrelated analysis of variance showed significant differences for the nine factors for at least one or more user group. For example, 'adequate illumination level in all spaces' differed significantly ($F = 104.33$, $df = (3, 24)$, $p < .001$) for physically disabled, visually impaired, elderly and adult groups. The F -ratios for between-groups effect for each factor are given in Table 5. However, this does not necessarily imply that all means were significantly different from each other. Multiple comparison tests were done in order to determine the group differences. Since the sample sizes were different in each

group, a Scheffe test was done. Table 5 lists the set of means that do not differ significantly from each other for each factor.

Based on the findings (see Tables 4 and 5), a priority-based list with the characteristic features of the 'design for all' approach for independent living is developed (Table 6). The following list of characteristics includes elements, features, ideas and concepts that contribute to the decision-making of designers with the 'design for all' approach. It is a dynamic list where more 'design for all' characteristics or features can be added.

As seen in Table 6, there are many characteristic features on the list and designers may prefer to avoid some of them. Fabrigar et al. (1999) suggested at least four measured items for each factor since principal component analysis produces substantially inflated estimates of factor loadings when there are less than four items. Therefore, Factors 7, 8 and 9 with three items can be avoided (see Tables 4 and 6) or regarded as relatively low-loaded factors in home designs.

In the 'adequate illumination level in all spaces' factor, Scheffe's range test found that the adult group differed from the physically disabled, visually impaired and elderly groups (each $p < .001$). No significant differences were found between physically disabled, visually impaired and elderly groups. The physically disabled, visually impaired and elderly people give more importance to an adequate illumination level in the home environment than adults. Recommended illumination levels are slightly higher for

Table 5. Homogeneous subsets of users as a result of Scheffe's test for each factor.

Factor	Scale	F -value	Scheffe's test subset for alpha = 0.05			
			1	2	3	4
1	Adequate illumination level in all spaces	$F_{3,24} = 104.33$ $p < .001$	Physically disabled Visually impaired Elderly	Adult		
2	Ease of use in the kitchen	$F_{3,12} = 1208.83$ $p < .001$	Visually impaired	Physically disabled	Elderly	Adult
3	Adequate space for approach and use	$F_{3,16} = 1299.04$ $p < .001$	Visually impaired	Elderly	Physically disabled	Adult
4	Adequate contrast between essential information and its surroundings	$F_{3,20} = 4487.00$ $p < .015$	Physically disabled Elderly Visually impaired	Elderly Visually impaired Adult		
5	Ease of use in accessories	$F_{3,16} = 121.76$ $p < .001$	Visually impaired Physically disabled	Physically disabled Elderly	Adult	
6	Functional vertical circulation	$F_{3,12} = 44.64$ $p < .001$	Visually impaired Elderly	Elderly Physically disabled	Adult	
7	Provision of privacy and safety in the bathroom	$F_{3,8} = 863.01$ $p < .001$	Visually impaired	Physically disabled Elderly	Adult	
8	Safety of floors in all spaces	$F_{3,8} = 3483.74$ $p < .001$	Visually impaired	Physically disabled	Elderly	Adult
9	Accessibility to all spaces	$F_{3,8} = 693.49$ $p < .001$	Visually impaired	Elderly Physically disabled	Adult	

elderly people (Table 6, items 34 and 22) and visually impaired, physically disabled and elderly people prefer lights in their closets (Table 6, items 53 and 38).

In the ‘ease of use in kitchen’ factor, Scheffe’s range test found that all the groups differed significantly from each other (each $p < .001$, except $p = .047$ between elderly and physically disabled groups). Ease of use in the kitchen is

very important for visually impaired people and relatively lower in importance for adults. Although all user groups agreed that appliances like cook-top, oven and refrigerator should be used easily, design solutions to provide ease show some varying details depending on the user group (Table 6). Thus, further customized solutions may be provided in the kitchen.

Table 6. A priority-based list with the characteristic features of the ‘design for all’ approach for independent living.

Adequate illumination level in all spaces	Visually impaired	Physically disabled	Elderly	Adult
34 Task lighting on top of counters in the kitchen (0.740)		300–1000 lux ^a	500–1000 lux ^a	300–1000 lux ^a
65 Adequate illumination for circulation spaces (0.733)		75 lux ^a	75 lux ^a	75 lux ^a
22 Adequate illumination in the bathroom (0.691)		200–300 lux ^a	300 lux ^a	200–300 lux ^a
60 Adequate illumination on top of the dining table (0.686)	Max. 215 lux ^b	150 lux ^a	150 lux ^a	150 lux ^a
27 Adequate illumination in the kitchen (0.681)		75 lux ^a	75 lux ^a	75 lux ^a
53 Closet interiors to be illuminated in the bedroom (0.678)	Lights should be provided in closets. Closets should be illuminated by a switch that is activated when the door is opened ^b			
38 To have illumination inside kitchen cabinets (0.678)				Vertical lighting to facilitate the task of finding things in the cupboards ^c
Ease of use in the kitchen	Visually impaired	Physically disabled	Elderly	Adult
41 Cook-top to be used easily (0.841)	Cook-top with staggered burners and front- or side-mounted controls ^d	Controls shaped to facilitate gripping ^e		
42 Oven to be used easily (0.778)	Burner locations should be identified ^f	Cook-top with knee space below ^d		
40 Refrigerator to be used easily (0.705)	Side-opening oven at countertop height with side shelf ^f	Oven controls on the front panel ^e	Built-in oven with knee space beside it ^d	
45 All appliances to be provided with sufficient clear floor area in the kitchen (0.617)	Side-by-side refrigerator with pull-out shelves ^d	Continuous door handles ^e	Front-mounted control ^e	
		A clear floor space in front of all appliances ^e		
Adequate space for approach and use	Visually impaired	Physically disabled	Elderly	Adult
50 To move/manoeuvre easily in the bedroom (0.803)	Bedroom areas should be large enough to accommodate normal furnishings and adequate space for traffic ^g			
49 Bedroom to provide adequate space for the activities (0.757)	There should be a minimum of 91.4 cm at the foot of the bed and the far side of the bed to facilitate circulation, cleaning, bed changing and bed making ^e			
59 To move/manoeuvre easily in the living room (0.725)	There should be at least one clear space for 180 degree turns ^e			
58 To have adequate space in the living room (0.684)	Provide large enough living areas to accommodate normal furnishings and adequate space for traffic ^g			
73 All controls (light switches, window/door operators, electric outlets, etc.) to require little effort (0.533)	Light switches at 105 cm from floor level ^g			
	Easy touch rocker or hands-free switches ^d			
	Electrical outlets at 45 cm from floor level ^g			
	Control panels, thermostat controls at 120 cm from floor level ^g			

(Continued)

Table 6. Continued.

Adequate contrast between essential information and its surroundings	Visually impaired	Physically disabled	Elderly	Adult
31 To have colour contrast between the sink and counter in the kitchen (0.810)	If features are to be identified, there must be a distinct colour change to highlight the feature ^h	Contrast is desired between the object to be viewed and its immediate surround as visibility increases as contrast increases		
35 To have colour contrast between the counter and cabinets in the kitchen (0.789)	Maximum contrast is needed	As age increases, normal-sighted persons need an optimum contrast of visual tasks to achieve best visual performance ⁱ Optimum contrast is needed		
56 To have colour contrast between storage handles and storage doors in the bedroom (0.774)				
17 To have colour contrast between the counter top and lavatory in the bathroom (0.733)				
75 Light switches to have colour contrast with walls (0.719)				
Ease of use in accessories	Visually impaired	Physically disabled	Elderly	Adult
36 Cabinet handles to be used easily in the kitchen (0.617)	Handles that do not require gripping or twisting. Handles on base cabinet doors should be mounted as high as possible and on wall cabinets as low as possible ^j			
54 Closet handles to be used easily in the bedroom (0.564)	Handles that do not require gripping or twisting. Usable when equipped with pull bars or fixed loops ^j			
55 Closet handles to fit any hand in the bedroom (0.551)	Usable when equipped with pull bars or fixed loops ^j			
33 Main counter to be used easily in the kitchen (0.543)	Adjustable height (71-91.5cm) work surface ^e			
18 Faucets to be used easily in the bathroom (0.535)	Single-lever water controls in all plumbing fixtures and faucets ^d			
Functional vertical circulation	Visually impaired	Physically disabled	Elderly	Adult
71 Ramp slopes to be appropriate (0.814)		The maximum slope of a ramp shall be 1:12 ^e		
72 Ramps to have curbs or lips on the sides (0.772)		Side curb height 5.1 cm ^e		
69 Staircases to be single flight, without a turn (0.654)	Straight-run stairway ^g			
70 Handrails to be continuous and easily grasped (0.650)	Handrails shall be continuous along both sides of the stairs. The diameter or width of the gripping surface of a handrail shall be 3.2–3.8 cm ^e			
Provision of privacy and safety in the bathroom	Visually impaired	Physically disabled	Elderly	Adult
20 Toilet to be used without help (0.809)	Standard height toilet ^g Wall reinforcement to provide grab bars near the toilet ^g Clear space in front and to one side of the toilet according to the designed space: allows for easy manoeuvring to and around toilet ^d			
13 Tub/shower to be used without help (0.796)	Tub with free space along the entire length ^g Shower with no threshold ^g Wall reinforcement to provide grab bars in the bath and shower ^g Adjustable height shower head ^g			
21 Toilets to be used with low effort and minimum fatigue (0.665)	Easy approach to the toilet Ease of use in use of controls Reachable toilet paper dispenser ^b			

(Continued)

Table 6. Continued.

Safety of floors in all spaces	Visually impaired	Physically disabled	Elderly	Adult
44 Floor to be slip-resistant in the kitchen (0.893)	Non-slip flooring ^g			
24 Floor to be slip-resistant in the bathroom (0.844)	Non-slip flooring ^g			
64 Floor to be slip-resistant in circulation spaces (0.754)	Non-slip flooring ^g			
Accessibility to all spaces	Visually impaired	Physically disabled	Elderly	Adult
62 To have access to all rooms through circulation spaces (0.694)	Access to all spaces ^g			
63 Corridors to provide adequate space for passage and manoeuvring (0.644)	Corridors' minimum width should be 150 cm ^g			
26 To move/manoeuvre easily in the kitchen (0.620)	There should be at least one clear space for 180 degree turns ^e There should be at least one clear space for 180 degree turns ^e			

^aKaufman and Christensen (1987).

^bRaschko (1982).

^cPhilips Lighting (1993).

^dMace (1998).

^eANSI A117.1 (1986).

^fThe Center for Universal Design (2000).

^gFlexHousing™ Pocket Planner (2006).

^hBright, Cook, and Harris (n.d.).

ⁱEgan (1983).

^jMace et al. (1991).

In the 'adequate space for approach and use' factor, Scheffe's range test found that all the groups differed significantly from each other (each $p < .001$, except $p = .038$ between elderly and physically disabled groups). This factor is very important for visually impaired people, while being relatively lower in importance for adults. Nevertheless, all groups desired to have enough space in bedrooms and living rooms (Table 6).

In the 'adequate contrast between essential information and its surroundings' factor, no significant difference was found between physically disabled, visually impaired and elderly groups. Also, no significant difference was found between elderly, visually impaired and adult groups. The highest significant difference was found between adult and physically disabled groups ($p = .032$), which resulted in two subsets. This factor only has two subsets with overlapping user groups. Current recommendations for using adequate contrast are limited (Table 6). As adequate contrast is desired in our home environments, the subject needs to be further researched and studied.

In the 'ease of use in accessories' factor, no significant difference was found between visually impaired and physically disabled groups. Also, no significant difference was found between physically disabled and elderly groups. The adult group differed significantly from the other two groups ($p < .001$). This factor is more important to visually impaired and physically disabled people than adults.

For all user groups cabinet and closet handles, faucets and kitchen counter are the most important accessories in a home (Table 6).

In the 'functional vertical circulation factor', no significant difference was found between visually impaired and elderly groups. Also, no significant difference was found between elderly and physically disabled groups. The adult group differed significantly from the other two groups ($p < .001$). Elderly people seem to give importance to similar aspects as visually impaired people as well as physically disabled people. This may be due to the deterioration of sight and movement with aging. Appropriate ramp slopes, side-curbs and straight-run stairways are all important for the elderly, the visually impaired and physically disabled people (Table 6).

In the 'provision of privacy and safety in bathroom' factor, visually impaired and adult groups each differed significantly from the other groups ($p < .001$). No significant difference was found between physically disabled and elderly groups. All user groups wish to use toilets, tubs and showers without help, with low effort and minimum fatigue (Table 6), where visually impaired people seem to request this more strongly than the adult group.

In the 'safety of floors in all spaces' factor, Scheffe's range test found that all the groups differed significantly from each other. Visually impaired people give importance to non-slip flooring, which could be beneficial to all users (Table 6).

In the ‘accessibility to all spaces’ factor, no significant difference was found between elderly and physically disabled groups ($p = .849$). Visually impaired and adult groups are significantly different from the other groups. In this factor, corridors and kitchen are especially emphasized to be important for access and manoeuvring (Table 6).

Conclusion and implications for home design

The aim of the study is to prioritize diverse user needs in the design of homes. In this study, the nine factors that are important for a universally designed home are identified with the relevant ranked items. Furthermore, in each factor diverse user groups are considered. It is pointed out that all the groups do not differ significantly from each other for each factor. This is a pioneer study that groups diverse users under various factors that are the requirements in ‘design for all’ and the holistic perspective embedded in ‘design for all’ should be considered all through the design process. The results indicate that there is a synergy between usability and accessibility as one can be considered as a category of another during the design process.

Although each country has its own building regulations, standards, references and norms, designers should not perceive these data merely as a set of rules for applying them in the design process. Effective and efficient knowledge is crucial for the ‘design for all’ approach in the design process (Afacan and Demirkan 2011). Therefore, there should be some knowledge support for designers in developing satisfactory ‘design for all’ solutions in the design process. The following checklist with the priorities listed from high to low can be a guide for home designers in the design process (Table 7).

In this study, different user groups agreed upon the importance of the same factors. All users gave the most importance to adequate illumination level (priority 1, in Table 7) followed by eight other factors related to ease of use, space provision, contrast information, accessibility, safety and privacy in different parts of a house (Table 7). The users gave importance to all spaces of a house, emphasizing especially, in the order of importance, kitchen (priority 2), bedroom and living room (priority 3), vertical circulation (priority 6) and bathroom (priority 7) (see Table 7). Thus, the factors needing special attention do not vary among different user groups that support the ‘design for all’ approach. Designers should not change their priorities according to a single user group, but concentrate on designing for all people.

In the design process, the role of a designer is to make decisions about the designed spaces for diversified population. Mostly, accessibility features are integrated into a design, but the basic premise behind the ‘design for all’ approach is to determine and prioritize the issues that are important for diverse users. This study emphasized that adequate illumination in various spaces and on work surfaces was the main design issue with the highest priority

to be considered by the design practitioners. It can be concluded that accessibility to the physical environment should be achieved, but more than that adequate illumination should be provided in all spaces and on work surfaces. Table 6 documents the relevant requirements for diverse user groups and the related sources. This priority should be satisfied in all design processes.

It is followed by the ease of use in kitchen appliances, which holds a second rank in priority. Furthermore, all the appliances of appropriate sizes should be installed with space provided for approach, reach, manipulation and use (see Table 6). Furthermore, there should be adequate contrast between the sink and kitchen counter, and kitchen counter and cabinets (priority 4); ease of use in cabinet handles and use of main counter in kitchen (priority 5). It can be concluded that the kitchen is an important space for the ‘design for all’ approach as stated in the literature (Afacan and Demirkan 2010) and all the activities conducted in the kitchen should be done efficiently and comfortably.

The third priority belongs to providing adequate space for doing the activities efficiently and comfortably in the bedroom and living room. Moreover, there should be adequate space for moving and manoeuvring in both bedroom and living room. All the operating controls such as light switches, window/door operators, electric outlets should be easy to reach and operated efficiently (see Table 6). The design implications for home designers were developed in detail as a priority-based list with the relevant characteristic features of the ‘design for all’ approach for independent living as depicted in Table 6. This table includes elements, features, ideas and concepts that contribute to the decision-making process of designers with the ‘design for all’ approach. As Steinfeld and Maisel (2012) stated, universal design should enable and empower a diverse population by improving human performance, health and wellness. The success of this approach can be realized by the proper decision-making process of the designers.

The work presented here is subject to limitations. The diversified participants were physically disabled, visually impaired or elderly individuals. There were no multiple or mentally disabled subjects. People with disabilities have a vast range of abilities and impairments. For future studies, other sensory or cognitive impaired subjects or individuals with multiple disabilities could be included. In this way, the diversity of the population could be broadened. Extending beyond natural diversity, the people may have temporary health problems such as back pain or personal circumstances related to a specific activity as carrying a briefcase or a child. Duncan (2007) stated, ‘perhaps it is more useful to think of everyone as possessing varying degrees of ability and disability instead of either fully-abled or disabled’ (16). It is well known fact that each person’s characteristics can vary widely from others and during their lifespan. Furthermore, there may be cultural differences that

Table 7. A checklist as a guide for home designers.

	Priority list (ranking from high to low)	Yes	No	N/A
1	Is there adequate illumination (a) On top of counters in the kitchen? (b) In circulation spaces? (c) In the bathroom? (d) On top of the dining table? (e) In the kitchen? (f) In closet interiors in the bedroom? (g) Inside kitchen cabinets?			
2	Is there ease of use in the kitchen for (a) Cook-top? (b) Oven? (c) Refrigerator? (d) All appliances with sufficient clear floor area in front?			
3	Is there adequate space (a) To move/manoeuvre in the bedroom? (b) For activities in the bedroom? (c) To move/manoeuvre in the living room? (d) For activities in the living room? (e) For operating all controls (light switches, electric outlets, etc.)?			
4	Is there adequate contrast between (a) Sink and kitchen counter? (b) Kitchen counter and cabinets? (c) Bedroom storage handles and doors? (d) Bathroom counter top and lavatory? (e) Light switches and walls?			
5	Is there ease of use in (a) Cabinet handles in kitchen? (b) Closet handles in bedroom? (c) Any hand-fitting closet handles? (d) Main counter in kitchen? (e) Faucets in bathroom?			
6	Is there functional vertical circulation as (a) Ramps with appropriate slope? (b) Ramps with curbs or lips on the sides? (c) Straight-run stairways? (d) Continuous stair handrails with easy grasp?			
7	Is there privacy and safety in the bathroom in use of (a) Toilet? (b) Tub/Shower? (c) Approach to toilet, use of toilet controls and reach to toilet paper dispenser?			
8	Are there non-slip floor surfaces in (a) Kitchen? (b) Bathroom? (c) Circulation spaces?			
9	Is there accessibility to (a) All rooms through circulation spaces? (b) Corridors providing passage and manoeuvring space? (c) Kitchen to move/manoeuvre?			

affect the diversified user groups; therefore the study could be repeated in different countries also including the social participation issue. This work may be a guide for designers to provide safe and functionally appropriate environments for all users.

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Appendix

SURVEY

Please tick the appropriate box for each item.

	Least important				Most important
Entrance of the main building	1	2	3	4	5
1. Entrance to be clearly visible from parking lot.					
2. To have accessible pathway between parking lot and the main entrance.					
3. Entrance to be adequately lit from outside.					
4. Entrance door to be usable by all people.					

	Least important				Most important
Home entrance	1	2	3	4	5
5. Door to be wide enough to pass through with ease.					
6. Door handle to be operated with closed fist or elbow.					
7. Door handle to accommodate any hand size.					
8. Door hardware to be used easily with low physical effort.					
9. Visitors who come to the door to be seen without opening it.					
10. Adequate illumination.					

	Least important				Most important
Bathroom	1	2	3	4	5
11. Bathroom to provide adequate space for bathroom activities.					
12. Thresholds to be level with the floor or ramped.					
13. Tub/shower to be used without help.					

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14. To have grab bars around bathroom units.					
15. Bath/shower valves to be used easily.					
16. Lavatory to be used easily.					
17. To have color contrast between counter top and lavatory.					
18. Faucets to be used easily.					
19. To use the bath mirror.					
20. Toilet to be used without help.					
21. Toilets to be used with low-effort and minimum fatigue.					
22. Adequate illumination.					
23. To have ground-fault interrupter (GFI) electrical outlet.					
24. Floor to be slip-resistant.					
25. Door to open towards outside.					

	Least important				Most important
Kitchen	1	2	3	4	5
26. To move/maneuver easily in the kitchen.					
27. Adequate illumination.					
28. Sink to be used easily.					
29. Faucets to be used easily.					
30. Sink pipes to be insulated, covered or shielded.					
31. To have color contrast between sink and counter.					
32. Work surfaces to be at various heights.					
33. Main counter to be used easily.					
34. Task lighting on top of counters.					
35. To have color contrast between counter and cabinets.					
36. Cabinet handles to be used easily.					
37. Cabinets to have pullout shelves.					
38. To have illumination inside of kitchen cabinets.					
39. Upper cabinets to be accessible.					
40. Refrigerator to be used easily.					
41. Cook-top to be used easily.					
42. Oven to be used easily.					
43. To have ground-fault circuit interrupter (GFI) outlets for					

small electrical appliances.					
44. Floor to be slip-resistant.					
45. All appliances to be provided with sufficient clear floor area.					
46. To have short distance between the kitchen and the dining table.					
47. Counter to have pullout surfaces.					
48. To have enough electrical outlets.					

	Least important				Most important
Bedroom	1	2	3	4	5
49. Bedroom to provide adequate space for the activities.					
50. To move/maneuver easily in bedroom.					
51. Bed to be used easily.					
52. Closets to be used easily.					
53. Closet interiors to be illuminated.					
54. Closet handles to be used easily.					
55. Closet handles to fit any hand.)					
56. To have color contrast between storage handles and storage doors.					
57. To have light switch at bedside.					

	Least important				Most important
Living room	1	2	3	4	5
58. To have adequate space in living room.					
59. To move/maneuver easily in living room.					
60. Adequate illumination on top of dining table.					
61. To have additional electrical outlets.					