Develop a bedroom design guideline for progressive ageing residence: A case study of Indonesian older adults

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N. Rahmawati, B.C. Jiang. Develop a bedroom design guideline for progressive ageing residence: A case study of Indonesian older adults. Gerontechnology 2019;18(3):180-192; https://doi.org/10.4017/gt.2019.18.3.005.00 Most of the older adults in the world prefer to remain in their current residence as long as possible. It is important to support the older adults live independently. Several studies have been done on the appropriate house design for the older adults, but only limited studies are available on the bedroom design. Therefore, this study aims to develop an appropriate bedroom design for the older adults by applying human factors principles. A total of 11 Indonesian bedrooms were selected as the representatives for the design evaluation. This evaluation was conducted by using bedroom design checklists with 5 points score and the checklists were classified into three subgroups based on the older physical ratings: independent, cane required, and wheelchairs required. As a recommendation, the selection of 15 body dimensions was considered in the design of elderly bedroom. In the end of this study, the guidelines were presented to design appropriate bedroom for the older adults.

Keywords: older adults, human factor principles, Indonesian bedrooms, bedroom guidelines design

Introduction

The number of elderly populations in Indonesia reached over 20 million or 8.03% of the total population in 2014 (Statistics Indonesia [BPS], 2014). This led Indonesia into one of the countries with the ageing population structure because the number has reached over 7% of the total population ("Bulletin of Health Information and Data," 2013). The increasing number of elderly populations affects the increasing proportion of elderly persons to live independently. Based on the entire population in Indonesia, 18.1% older adults lived only with their spouse and even 9.8% of them lived alone (United Nations Population Fund Indonesia [UNFPA], 2014). Most of the older adults in the world prefer to age in place as long as possible rather than move to a new community such as nursing home (American Association of Retired Persons [AARP], 2011). The older people do not want to lose their connection to the neighborhood they have built. This is one of the reasons that the older people still want to stay in their current residence.

However, the challenge in supporting the elderly to live at risk in their own home are to provide safe home for them. There are some environmental constraints that prevent elderly live independently (Wahl, Fänge, Oswald, Gitlin, & Iwarsson, 2009). Therefore, the elderly need environments and facilities that support their daily life safely (Md Dawal et al., 2015). Furthermore, the proportion of older persons with disability increased with age. Aging is usually accompanied by physical function decline (Harma, 1996). Of the total population, 26% reported having one or more forms of disability (UNFPA Indonesia, 2014). In design, this physical decline or disability must be taken into consideration. It cannot be assumed that one design will meet all of elderly needs (Parsons, 1981).

Several studies have highlighted appropriate house design for the elderly such as bathroom design (Md Dawal et al., 2015; Rashid, Hussain & Yusuf, 2008; Afifi, Al-Hussein, & Bouferguene, 2015; Jiang, Chien & Lee, 2016) and kitchen design (Camara, De Castro Engler & De Oliveira Fonseca, 2010; Taha & Sulaiman, 2010; Chang &

Table 1. Evaluation checklist based on previous study

Items	Physical rating		
	Independent	**Cane required**	**Wheelchair required**
Entrance width	Entrance width min 800mm *(Ministry of Public Works of Indonesia, 2006)*	Entrance width min 900 mm [elbow span, 95th male] *(Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Entrance width min 900 mm [elbow span, 95th male] *(Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006; Seo-Ryeung & You-Jin, 2004)*
Door style	Door style should be sliding or swing door *(Parsons, 1981)*	Door style should be sliding or swing door *(Parsons, 1981)*	Sliding door is recommended *(Parsons, 1981)*
Swing doors	Swing door should be open at 90 degrees *(Building and Construction Authority of Singapore, 2013)*	Swing door should be open at 90 degrees *(Building and Construction Authority of Singapore, 2013)*	Swing door should be open at 90 degrees *(Building and Construction Authority of Singapore, 2013)*
Door colors	Door should have contrast colors *(Seo-Ryeung & You-Jin, 2004)*	Door should have contrast colors *(Seo-Ryeung & You-Jin, 2004)*	Door should have contrast colors *(Seo-Ryeung & You-Jin, 2004)*
Door handle height	Door handle height max 1010 mm from the finished floor [standing elbow height, 95th female] *(Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Door handle height max 1010 mm from the finished floor [standing elbow height, 95th female] *(Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Door handle height: 900 mm *(Rashid, Hussain, & Yusuf, 2008; Md Dawal et al., 2015)*
Door handle length	Door handle length should be 140 mm ("D" or loop handle type) or 100 mm (lever handle type) *(Building and Construction Authority of Singapore, 2013)*	Door handle length should be 140 mm ("D" or loop handle type) or 100 mm (lever handle type) *(Building and Construction Authority of Singapore, 2013)*	Door handle length should be 140 mm ("D" or loop handle type) or 100 mm (lever handle type) *(Building and Construction Authority of Singapore, 2013)*
Distance handle from face door	Distance handle from face door should be 45 mm *(Building and Construction Authority of Singapore, 2013)*	Distance handle from face door should be 45 mm *(Building and Construction Authority of Singapore, 2013)*	Distance handle from face door should be 45 mm *(Building and Construction Authority of Singapore, 2013)*
Door handle style	Door handle style should be lever type or "D" shape (loop handle) *(Parsons, 1981;Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Door handle style should be lever type or "D" shape (loop handle) *(Parsons, 1981;Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Automatic door handle is more recommended *(Parsons, 1981;Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*
Door handle colors	Door handle should have contrast colors from the door itself *(Building and Construction Authority of Singapore, 2013)*	Door handle should have contrast colors from the door itself *(Building and Construction Authority of Singapore, 2013)*	Door handle should have contrast colors from the door itself *(Building and Construction Authority of Singapore, 2013)*
Door handle edges	Door handle should have round in lever cross-section with no sharp edges *(Parsons, 1981)*	Door handle should have round in lever cross-section with no sharp edges *(Parsons, 1981)*	Door handle should have round in lever cross-section with no sharp edges *(Parsons, 1981)*
Bed height	Bed height: 380 mm [sitting popliteal height, 5th female] *(Dvouleta & Kanova, 2014; Parsons, 1981; Ministry of Public Works of Indonesia, 2006)*	Bed height: 380 mm [sitting popliteal height, 5th female] *(Dvouleta & Kanova, 2014; Parsons, 1981; Ministry of Public Works of Indonesia, 2006)*	Bed height: 500 mm [sitting popliteal height, 95th female] *(Parsons, 1981; Ministry of Public Works of Indonesia, 2006)*
Bed length	Bed length: 1755 mm (stature, 95th male) *(Dvouleta & Kanova, 2014)*	Bed length: 1755mm (stature, 95th male) *(Dvouleta & Kanova, 2014)*	Bed length: 1755 mm (stature, 95th male) *(Dvouleta & Kanova, 2014)*
Bed width	Bed width: 1500 mm (2 elbow span, 5th male for double beds) and 750 mm (elbow span, 5th male for single bed) *(Dvouleta & Kanova, 2014)*	Bed width: 1500 mm (2 elbow span, 5th male for double beds) and 750 mm (elbow span, 5th male for single bed) *(Dvouleta & Kanova, 2014)*	Bed width: 1500 mm (2 elbow span, 5th male for double beds) and 750 mm (elbow span, 5th male for single bed) *(Dvouleta & Kanova, 2014)*

Jiang, 2017). However, in Indonesia, only limited research has been conducted in elderly home design such as living and dining room design (Octavia & Widjaja, 2013). It is encouraged to continue the research effort in different topic area. Bedroom are places where the older adults spend a lot of time to rest especially for the ones who are not active independently. Therefore, this study aims to develop an appropriate bedroom design for Indonesian older adults by considering physical ability.

Methods

Progressive ageing, that is, a person is getting older gradually while he/she lives in the same house and may use the same bedroom; and

Table 1. Evaluation checklist based on previous study (cont.)

Items	Physical rating		
	Independent	**Cane required**	**Wheelchair required**
Bed corners	Bed should have rounded or softened corners *(Parsons, 1981)*	Bed should have rounded or softened corners *(Parsons, 1981)*	Bed should have rounded or softened corners *(Parsons, 1981)*
Bed position	Bed should be positioned in a way that allowed the elderly to see the door *(Sporrle & Stich, 2010)*	Bed should be positioned in a way that allowed the elderly to see the door *(Sporrle & Stich, 2010)*	Bed should be positioned in a way that allowed the elderly to see the door *(Sporrle & Stich, 2010)*
Wardrobe height	Wardrobe height: 1650 mm (standing vertical grip reach, 5th female) *(Ministry of Public Works of Indonesia, 2006)*	Wardrobe height: 1650 mm (standing vertical grip reach, 5th female) *(Ministry of Public Works of Indonesia, 2006)*	Hanger rod height in wardrobe: 1350 mm (sitting vertical grip reach, 5th female) *(Ministry of Public Works of Indonesia, 2006)*
Wardrobe depth	Wardrobe depth: 520 mm (shoulder-grip length, 5th female) *(Scottish Association of Building Standards Managers, 2009)*	Wardrobe depth: 500 mm *(Building and Construction Authority of Singapore, 2013)*	Wardrobe depth: 500 mm *(Building and Construction Authority of Singapore, 2013)*
Wardrobe corners	Wardrobe corners should be rounded *(Parsons, 1981)*	Wardrobe corners should be rounded *(Parsons, 1981)*	Wardrobe corners should be rounded *(Parsons, 1981)*
Wardrobe door handle height	Wardrobe door handle height max is 1010 mm (standing elbow height, 95th female) *(Rashid, Hussain, & Yusuf, 2008)*	Wardrobe door handle height max is 1010 mm (standing elbow height, 95th female) *(Rashid, Hussain, & Yusuf, 2008)*	Wardrobe door handle height: 900 mm *(Building and Construction Authority of Singapore, 2013)*
Wardrobe clearance height			Wardrobe toe clearance height: 250 mm *(Ministry of Public Works of Indonesia, 2006)*
Wardrobe clearance depth			Wardrobe toe clearance depth: 150 mm *(Ministry of Public Works of Indonesia, 2006)*
Chair height	Chair height is max 380 mm (sitting popliteal height, 5th female) *(Md Dawal et al., 2015)*	Chair height is max 380 mm (sitting popliteal height, 5th female) *(Md Dawal et al., 2015)*	
Chair depth	Chair depth is min 360 mm [buttock-popliteal length, 5th female] *(Md Dawal et al., 2015)*	Chair depth is min 360 mm [buttock-popliteal length, 5th female] *(Md Dawal et al., 2015)*	
Chair width	Chair width is min 440 mm [hip breadth, 95th female] *(Md Dawal et al., 2015)*	Chair width is min 440 mm [hip breadth, 95th female] *(Md Dawal et al., 2015)*	
Chair arm rest height	Chair arm rest height: 150 mm [sitting elbow height, 5th female] *(Md Dawal et al., 2015)*	Chair arm rest height: 150 mm [sitting elbow height, 5th female] *(Md Dawal et al., 2015)*	
Chair arm rest style	Chair arm rest style should be easy to grasp *(Parsons, 1981)*	Chair arm rest style should be easy to grasp *(Parsons, 1981)*	
Chair back rest height	Chair back rest height is min 570 mm [sitting shoulder height, 95th female] *(Md Dawal et al., 2015)*	Chair back rest height is min 570 mm [sitting shoulder height, 95th female] *(Md Dawal et al., 2015)*	
Chair back rest width	Chair back rest width is min 490 mm [shoulder breadth, 95th male] *(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*	Chair back rest width is min 490 mm [shoulder breadth, 95th male] *(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*	

therefore, there is a need to consider the different stage of aging while using bedroom. In this study, bedroom guidelines were developed to accommodate the progressive ageing. A series of design checklist consisting of several bedroom items were collected to develop guidelines. The design checklist were obtained by reviewing several studies that have been done previously in the same area. Different stage of aging to develop the bedroom design checklist and guidelines are divided into three categories, that is, wheelchairs, cane required and independent elderly. Different stages of aging are intended to accommodate physical decline or disability of the older adults.

Table 1. Evaluation checklist based on previous study (cont.)

Items	Physical rating		
	Independent	**Cane required**	**Wheelchair required**
Chair edges	Chair should have rollaway leading at each of edge *(Parsons, 1981)*	Chair should have rollaway leading at each of edge *(Parsons, 1981)*	
Table/work surfaces height	Table/work surfaces height: min 700 mm, max 800 mm *(Ministry of Public Works of Indonesia, 2006)*	Table/work surfaces height: min 700 mm, max 800 mm *(Ministry of Public Works of Indonesia, 2006)*	Table/work surfaces height: min 700 mm, max 800 mm *(Ministry of Public Works of Indonesia, 2006)*
Table/work surfaces depth	Table/work surfaces depth: min 500 mm *(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*	Table/work surfaces depth: min 500 mm *(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*	Table/work surfaces depth: min 500 mm *(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*
Table/work surfaces width	Table/work surfaces width min 760 mm *(Ministry of Public Works of Indonesia, 2006)*	Table/work surfaces width min 760 mm *(Ministry of Public Works of Indonesia, 2006)*	Table/work surfaces width min 760 mm *(Ministry of Public Works of Indonesia, 2006)*
Table surface	Table should have a surface texture that enables dry hands to grip it in rising and sitting *(Parsons, 1981)*	Table should have a surface texture that enables dry hands to grip it in rising and sitting *(Parsons, 1981)*	Table should have a surface texture that enables dry hands to grip it in rising and sitting *(Parsons, 1981)*
Table corners	Table corners should be rounded *(Parsons, 1981)*	Table corners should be rounded *(Parsons, 1981)*	Table corners should be rounded *(Parsons, 1981)*
Bedside table height	Bedside table height: 500 mm *(Ministry of Public Works of Indonesia, 2006)*	Bedside table height: 500 mm *(Ministry of Public Works of Indonesia, 2006)*	Bedside table height: 500 mm *(Ministry of Public Works of Indonesia, 2006)*
Bedside table depth	Bedside table depth: 406 mm *(Parsons, 1981)*	Bedside table depth: 406 mm *(Parsons, 1981)*	Bedside table depth: 406 mm *(Parsons, 1981)*
Bedside table width	Bedside table width: 508 mm *(Parsons, 1981)*	Bedside table width: 508 mm *(Parsons, 1981)*	Bedside table width: 508 mm *(Parsons, 1981)*
Bedside table corners	Bedside table corners should be rounded *(Parsons, 1981)*	Bedside table corners should be rounded *(Parsons, 1981)*	Bedside table corners should be rounded *(Parsons, 1981)*
Window height	Window height: Max 1650 mm (standing eye height of the 95th male) and min 570 mm [sitting eye height of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*	Window height: Max 1650 mm (standing eye height of the 95th male) and min 570 mm [sitting eye height of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*	Window height: Max 1650 mm (standing eye height of the 95th male) and min 570 mm sitting eye height of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*
Window style	Window style could be operable using one hand and not require fine finger control, tight grasping, pinching, or twisting of the wrist to operate *(The City of Winnipeg Universal Design, 2015)*	Window style could be operable using one hand and not require fine finger control, tight grasping, pinching, or twisting of the wrist to operate *(The City of Winnipeg Universal Design, 2015)*	Window style could be operable using one hand and not require fine finger control, tight grasping, pinching, or twisting of the wrist to operate *(The City of Winnipeg Universal Design, 2015)*
Window handle height	Window handle height: 1200 mm [standing shoulder height of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*	Window handle height: 1200 mm [standing shoulder height of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*	Window handle height: 1010 mm sitting vertical grip reach of the 5th female] *(Rashid, Hussain, & Yusuf, 2008)*
Curtain	Curtain should be provided at windows where direct sunlight can adversely affect the level of lighting and/or reflected glare *(Parsons, 1981; The City of Winnipeg Universal Design, 2015)*	Curtain should be provided at windows where direct sunlight can adversely affect the level of lighting and/or reflected glare *(Parsons, 1981; The City of Winnipeg Universal Design, 2015)*	Curtain should be provided at windows where direct sunlight can adversely affect the level of lighting and/or reflected glare *Parsons, 1981; The City of Winnipeg Universal Design, 2015)*

The design checklist consists of several keywords that are useful for designing bedroom at the later stage. Examples of keywords in the design checklist are dimensions and styles of doors, windows, beds, wardrobes, tables, chairs, and more. Details of the checklist and reference designs used are presented in *Table 1*. The design checklist is then used as material to assess and evaluate the current condition of the bedroom.

Recently several studies focused on the design of elderly homes, but in Indonesia only limited research has discussed about the issue, especially the problem of the bedroom for older adults. Therefore, the design of elderly bedroom in Indonesia is a crucial problem to discuss. To demonstrate the use of the developed checklist, 11 samples of Indonesian bedroom were selected. Bedroom samples were obtained through obser-

Table 1. Evaluation checklist based on previous study (cont.)

Items	Physical rating		
	Independent	**Cane required**	**Wheelchair required**
Switch height	Switch height max 1200 mm (standing shoulder height of the 5th female) *(Rashid, Hussain, & Yusuf, 2008; Ministry of Public Works of Indonesia, 2006)*	Switch height max 1000 mm *(Ministry of Public Works of Indonesia, 2006)*	Switch height: 900 mm *(Building and Construction Authority of Singapore, 2013)*
Switch style	Switch style should be push-button switches rather than turn switches *(Parsons, 1981)*	Switch style should be push-button s witches rather than turn switches *(Parsons, 1981)*	Switch style should be push-button switches rather than turn switches *(Parsons, 1981)*
Switch coded	Switch should have color coded and / or shape coded to distinguish the push button *(Parsons, 1981)*	Switch should have color coded and / or shape coded to distinguish the push button *(Parsons, 1981)*	Switch should have color coded and / or shape coded to distinguish the push button *(Parsons, 1981)*
Socket height	Socket height should be between 500mm and 1200mm above the floor *(Rashid, Hussain, & Yusuf, 2008)*	Socket height should be between 500mm and 1200mm above the floor *(Rashid, Hussain, & Yusuf, 2008)*	Socket height should be between 500mm and 900mm above the floor *(Scottish Association of Building Standards Managers, 2009)*
Lighting	The basic lighting should be 150 lux and night lighting should be reduced to 50 lux *(Seo-Ryeung & You-Jin, 2004)*	The basic lighting should be 150 lux and night lighting should be reduced to 50 lux *(Seo-Ryeung & You-Jin, 2004)*	The basic lighting should be 150 lux and night lighting should be reduced to 50 lux *(Seo-Ryeung & You-Jin, 2004)*
Temperature	Temperature should be between 21° C-24° C *(Parsons, 1981)*	Temperature should be between 21° C-24° C *(Parsons, 1981)*	Temperature should be between 21° C-24° C *(Parsons, 1981)*
Ceiling	Ceiling should be positioned at the center *(Building and Construction Authority of Singapore, 2013)*	Ceiling should be positioned at the center *(Building and Construction Authority of Singapore, 2013)*	Ceiling should be positioned at the center *(Building and Construction Authority of Singapore, 2013)*
Floor material	Floor shall be use non-slippery material, matte finish material is better *(Seo-Ryeung & You-Jin, 2004)*	Floor shall be use non-slippery material, matte finish material is better *(Seo-Ryeung & You-Jin, 2004)*	Floor shall be use non-slippery material, matte finish material is better *(Seo-Ryeung & You-Jin, 2004)*
Wall	Walls should be in yellow color *(Parsons, 1981)*	Walls should be in yellow color *(Parsons, 1981)*	Walls should be in yellow color *(Parsons, 1981)*
Space		Clear space between objects for a cane access is 900 mm *(Ministry of Public Works of Indonesia, 2006)*	Clear space required for a wheelchair to make a 360-degree turn is 1500 mm x 1500 mm *(Ministry of Public Works of Indonesia, 2006; Seo-Ryeung & You-Jin, 2004)*

Table 2. Evaluation checklist based on previous study

Scale	Score
Completely not compliant design *If the dimension, environment or usability of the item completely not compliant with the guideline*	1
Slightly compliant design *If the dimension, environment or usability of the item slightly compliant with the guideline*	2
Moderately compliant design *If the dimension, environment or usability of the item moderately compliant with the guideline*	3
Mostly compliant design *If the dimension, environment or usability of the item mostly compliant with the guideline*	4
Completely compliant design *If the dimension, environment or usability of the item similar to the guideline*	5

vation of the homes of elderly respondents aged 55-90 years. Indonesian bedrooms have the same characteristics consisting of double beds, wardrobes, work desks and windows. Examples of elderly bedrooms in Indonesia based on observations are presented in *Figure 1*.

Evaluation of the current condition of the elderly bedroom is carried out through this observation. Each item in the elderly bedroom was assessed by researcher using 5 points score, ranging from 1 (completely not compliant design) to 5 (completely compliant design). Detailed of the evaluation assessment score presented in *Table 2*. This evaluation was conducted to find out whether the current condition of the elderly bedroom is in accordance with the design checklist or not, for example the width of the bedroom entrance is in accordance with the recommended dimensions in the design checklist.

Figure 1. Characteristic of Indonesian bedrooms.

Results and discussion

Based on bedroom evaluation assessment using 5 point scores, it revealed that most of the current condition of the bedroom have scored 4 points or bedroom designs are mostly in accordance with the design checklist (for independent and cane required design) and have scored 3 points or bedroom designs are moderately in accordance with the design checklist (for wheelchairs required design). Evaluation score of all respondents are presented in *Table 3*. Respondent 1 has the highest score compared to the others, with score 4.33 of independent elderly, 4.27 of cane required elderly and 3.90 of wheelchairs required elderly, respectively.

Most of the problems found in the current design is the dimension of each item have differences

Table 3. Evaluation score

Respondent	Evaluation score					
	Independent older adults		Cane required older adults		Wheelchairs required older adults	
	Score (average)	Scale	Score (average)	Scale	Score (average)	Scale
1	4.33	Mostly compliant design	4.27	Mostly compliant design	3.90	Moderately compliant design
2	4.22		4.17		3.79	
3	3.76	Moderately compliant design	3.68	Moderately compliant design	3.60	
4	4.07	Mostly compliant design	4.00	Mostly compliant design	3.85	
5	3.79	Moderately compliant design	3.74	Moderately compliant design	3.54	
6	3.98		3.95		3.55	
7	3.97		3.90		3.60	
8	3.62		3.52		3.29	
9	3.54		3.50		3.57	
10	4.13	Mostly compliant design	4.06	Mostly compliant design	3.86	
11	3.89	Moderately compliant design	3.79	Moderately compliant design	3.76	

Table 4. Summary of common problem found

Items	Findings
Entrance	6 out of 11 respondents have entrance width less than 800mm. Moreover 2 of them have a difference of more than 100mm for independent design. All of the respondents have entrance width less than 900mm (cane and wheelchairs required design). The largest difference is 230mm.
	6 out of 9 respondents have doo r handle height more than 900mm (wheelchair required design). The difference is more than 100mm.
Bed Area	9 out of 11 respondents have bed height more than the maximum requirement size of 380 mm (independent and cane required design).
	5 respondents have bed width less than the minimum requirement size for double beds type (1500 mm).
	8 out of 11 beds have no rounded or softened corners
	3 beds are not positioned in a way that allowed them to see the door.
Storage units	7 out of 8 wardrobes have height more than 1650mm (independent and cane required design). All of the wardrobes have height more than 1350mm (wheelchair required design).
	5 wardrobes have depth between 380-400mm whereas the guideline is 520 mm for independent design and 500mm for cane and wheelchair required design.
	8 wardrobe handle have height more than 900mm (wheelchair required design). The difference is more than 100mm.
	10 out of 11 respondents do not have wardrobe toe clearance. It will reduce the range of forward reach of wheelchair required elderly.
	3 respondents have wardrobe door handle style with knob type. Lever handled or 'D' type is more recommended.
Work Area	6 out of 9 chairs have height more than 380 mm. Higher chairs cannot accommodate the foot rest.
	6 out of 9 do not have arm rest feature and 4 of them do not have back rest feature in the chairs. Providing a arm rest and back rest feature is very important to accommodate a rest and meet comfort needs.
Work Area	3 tables/work surfaces depth have size less than 500mm. A deeper table is needed to accommodate foot rest or toe and knee clearance for wheelchair users.
	6 tables have no rounded corners. It should have rounded corners as a prevention to injury.
Window Area	9 out of 11 respondents have window maximum height more than 1650mm. While, total 4 out of 11 respondents have window minimum height less than 570mm.
	5 out of 11 respondents have window handle height more than 1200mm (independent and can required design). 7 out of 11 respondents have window handle height more than 1010mm (wheelchair required design). While, 4 respondents have window handle height that is too low. The height is between 500 mm-800 mm.
	5 out of 11 respondents have window handle style with knob type. This type is not recommended, it should be lever handled or 'D' type.
	4 respondents do not provide curtains at the window.

with the recommendation in the design checklist. However, the problems found differently depending on each of the group recommendations. As an example, bedroom only has enough entrance access for the independent older adults but has not enough access for wheelchairs required elderly. The common problem found is presented in *Table 4*.

Based on *Table 4*, it can be seen that the entrance design is currently less than 900mm, whereas the recommended dimensions for wheelchair required design are more. In the bed area, bed height more than the maximum requirement size of 380 mm, so that independent and cane required older adults will be difficult to stand up from the bed. In the storage units, wardrobe handle have height more than 900mm, it will be

Table 4. Summary of common problem found (cont.)

Items	Findings
Control Units	10 out of 11 respondents have switch height more than 1200mm (independent design). All respondents have switch height more than the maximum requirement size of 1000mm (cane required design) and 900mm (wheelchair required design).
	All the respondents do not have switch with color coded and / or shape coded.
	All the respondents have socket height more than the maximum requirement size of 1200mm (independent), 1000mm (cane required), and 900mm (wheelchair design).
Environment	4 out of 11 respondents have floor colors that did not contrast with the wall colors.
	6 out of 11 bedrooms do not have clear space for a wheelchair to make a 360-degree.

difficult for wheelchair required elderly. While the window handle height is too low for elderly because the height is between 500 mm-800 mm. Wheelchair required elderly will be difficult to reach it. All of control units design do not have switch with color coded and / or shape coded, it will be difficult to recognize the control units for elderly with dementia.

Based on the summary common problem found, this study recommends an improvement design of elderly bedroom by considering design checklist that have been done previously. Bedroom of respondent 1 is taken as a reference of the improvement design because this bedroom has the highest evaluation score. As a comparison, the 3D picture of the current design and recommended design are presented. *Figure 2* presents the current design of bedroom respondent 1.

The recommendation bedroom design are presented in *Figure 3*. The changes of the dimensions are showed in different lines. Dotted line indicates recommended dimensions for independent elderly design, dash-dot line for cane required elderly design and dashed line for wheelchair required elderly design. Solid line indicates recommended dimensions of all elderly subgroups design.

In the recommended design, the entrance width is increased from 740mm to 800mm (independent elderly) and 900mm (cane required and wheelchair required elderly). Door handle height in the current design is compliant to the guidelines because less than 1010mm (independent and cane required design). But it should be reduced to 900mm in wheelchair design. Door handle style should be lever type or "D" shape (loop handle) and should have round shape in lever cross-section. Both of type should have no sharp edges.

Bed height should be reduced from 530mm to 380mm in independent and cane required design. In wheelchair design, at least the hanger rod of the wardrobe should be maximum of 1350mm in height. Wardrobe door handle height is compliant for independent and cane required design, but it should be reduced to 900mm for wheelchair required design.

In the current design, window handle height is 1100mm. It is compliant for independent and cane required design, but it should be reduced to 1010mm for wheelchair required design. Curtains should be provided in the window. Switch height is 1530mm and socket height is 1450mm. It should be reduced to 1200mm for independent, 1000mm for cane required and 900mm for

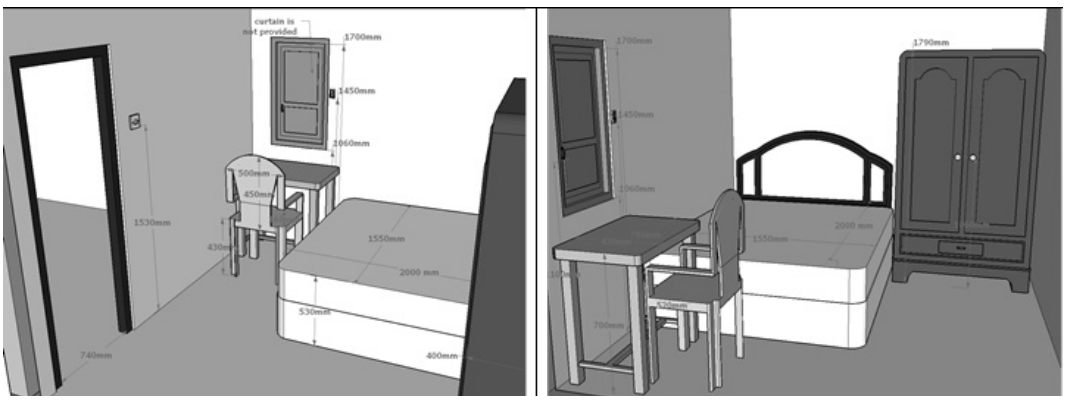

Figure 2. Current design of respondent 1 in 3D.

Table 5. Anthropometry body dimensions

Body dimensions	Male/female percentile	Dimension (mm)	Implementation in design	Reference
Stature	Male, 95th	1755	Bed length	*(Dvouleta & Kanova, 2014)*
Standing eye height	Male, 95th	1650	Max window height	*(Rashid, Hussain, & Yusuf, 2008)*
Standing shoulder height	Female, 5th	1200	Window handle, switch height	*(Rashid, Hussain, & Yusuf, 2008)*
Standing elbow height	Female, 95th	1010	Door handle height	*(Rashid, Hussain, & Yusuf, 2008)*
Standing vertical grip reach	Female, 5th	1650	Wardrobe height	*(Scottish Association of Building Standards Managers, 2009)*
Shoulder-grip length	Female, 5th	520	Wardrobe depth	*(Scottish Association of Building Standards Managers, 2009)*
Sitting shoulder height	Female, 95th	570	Chair back rest height	*(Md Dawal et al., 2015; Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*
Shoulder breadth	Male, 95th	490	Chair back rest width	*(Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*
Sitting eye height	Female, 5th	570	Min window height	*(Rashid, Hussain, & Yusuf, 2008)*
Sitting elbow height	Female, 5th	150	Chair arm rest height	*(Md Dawal et al., 2015; Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*
Sitting vertical grip reach	Female, 5th	1350	Window handle height	*(Scottish Association of Building Standards Managers, 2009)*
Elbow span	Male, 5th	750	Bed width	*(Dvouleta & Kanova, 2014)*
	Male, 95th	900	Entrance width	*(Rashid, Hussain, & Yusuf, 2008)*
Sitting popliteal height	Female, 5th	380	Bed height, Chair height	*(Dvouleta & Kanova, 2014)*
	Female, 95th	500	Bed height, Chair height (wheelchair)	*(Parsons, 1981)*
Buttock-popliteal length	Female, 5th	360	Chair depth	*(Md Dawal et al., 2015; Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*
Hip breadth	Female, 95th	440	Chair width	*(Md Dawal et al., 2015; Ismaila, Musa, Adejuyigbe & Akinyemi, 2013)*

wheelchairs required. Clear space to operate the window should be provided at least 900mm. Clear space required for a wheelchair turning (1500mm x 1500mm) should be provided.

At the end of the study, guidelines for designing a bedroom for the elderly were developed. Guidelines design were developed by considering design checklist and human factors principles. As the human factors principles, the selection of anthropometry body dimensions was considered to determine the item dimensions in the elderly bedrooms. All of the body dimensions refer to elderly anthropometric database of Ergonomic Laboratory of Islamic Indonesian University (2017) and it includes 15 body dimensions. The anthropometric data will be used to design several facilities on the bed, such as dimension of the door, window, bed, wardrobe, etc. The list of body dimensions that involved in the design were presented in *Table 5*. Bedroom design guidelines are presented in *Table 6*.

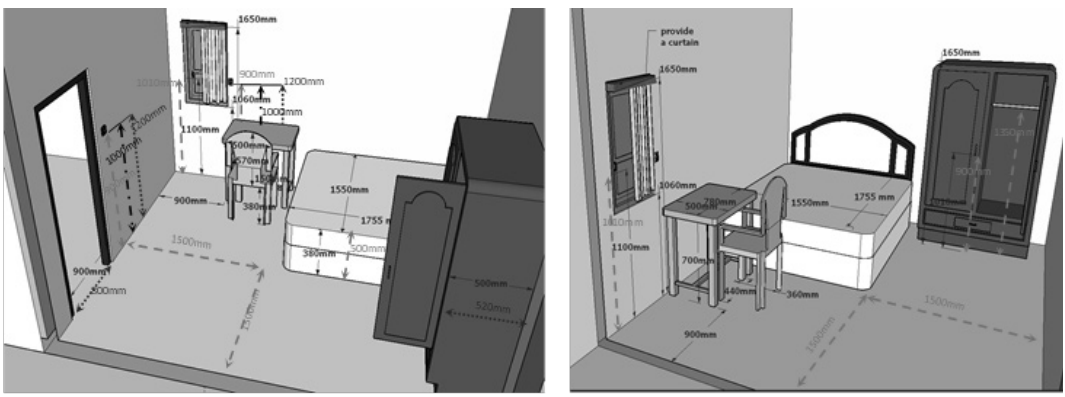

Figure 3. Recommended design of elderly bedroom in 3D.

Table 6. Bedroom design guidelines

Items	Guidelines
Entrance	Entrance width should be minimum 800mm for independent elderly and minimum 900mm for cane required and wheelchair required design.
	Door style should be sliding or swing doors. Swing doors type should be open at 90°. Sliding type is preferred for wheelchairs required rather than swing type because horizontal move is easier than 90° move.
	Door should have contrast colors to differentiate them from the surrounding environment. Threshold or sill are not recommended.
	Door handle height should be no higher than 1010mm and 900mm for wheelchair design.
	Door handle length should be 140mm ("D" or loop handle type) or 100mm (lever handles type) and it should have distance 45 mm from face door.
	Door handle style should be lever type or "D" shape (loop handle). Lever type should have round shape in lever cross-section and both should have no sharp edges.
Bed area	Bed height should be 380mm. The low enough bed will facilitate the elderly to stand up from the bed easily. While in wheelchair design, bed height should be 500 mm. It should have the same height as the wheelchairs so that the elderly can transfer from the wheelchairs to the bed easily.
	Bed size should be 1755mm in length and should be 1500mm in width for double bed and 750mm for single bed.
	Bed should have rounded or softened corners. Beds shall be accessible from two sides.
	Bed should be positioned in a way that allowed the elderly to see the door, psychologically, that position is influenced by intentions to avoid a draft coming from the entrance.
	Bedside should be 500mm in height, 406mm in depth and 508mm in width.
	Bedside table corners should have rounded shape.
Storage units	Wardrobe size should be 1650mm in height for independent and cane required design. In the wheelchairs required design, the wardrobe hanging bar should be 1350 mm in height. It should be reachable from the wheelchairs.
	Wardrobe depth should be 520mm for independent design. While, in the cane required and wheelchair required design, it should be 500mm in depth. It should accommodate the forward reach of cane and wheelchairs required elderly.
	At least 860mm in width for double leaf doors and the door should open through 180°.
	Wardrobe corners should be rounded as a precaution against injury.
	Wardrobe door handle height is 1010mm. In wheelchair design, it should be 900 mm. Wardrobe door handle style should be lever handled or 'D' type.
	In wheelchairs required design, the wardrobe should have wardrobe toe clearance 250 mm in height x 150 mm in depth.
	Shelves height should be maximum of 1400mm and minimum of 300mm for independent and cane required design. In the wheelchairs required design, it should be maximum of 1200mm and minimum of 405mm. While shelves depth should be 300mm-400mm. Shelves edges or corners should be rounded.

Figure 4(a) presents the guideline entrance of independent and cane required design and *Figure 4(b)* presents the guideline entrance of wheelchair required design. Entrance width should be minimum 800mm for independent elderly and minimum 900mm to accomodate cane required and wheelchair required older adults. In the recommendation, door style should be sliding or swing doors. Swing doors type should be open at 90°. Sliding type is preferred for wheelchairs required because horizontal move is easier than 90° move.

Guideline designs of front side position of the bedroom is presented in *Figure 5(a)* while guideline designs of plug/wire is presented in *Figure*

Table 6. Bedroom design guidelines (cont.)

Items	Guidelines
Work area	Chairs should be 380mm in height, 360mm in depth and 440mm in width.
	Chairs should have arm rest and back rest feature to accommodate a rest. The back-rest feature should be 570mm in height and 490mm in width. While the arm rest feature should be 150mm in height. Chair arm rest style should have round or roll edges to make it easy to grasp.
	Table/work surfaces height should be min 700 mm and max 800 mm.
	Table/work surfaces depth should be minimum 500 in depth and minimum 760 in width to accommodate the depth and width of chairs or wheelchairs.
	Table should have a surface texture that enables dry hands to grip it.
	Table corners should be rolled (rounded) to prevent injury.
Window area	Window height should be maximum 1650 mm and minimum 570 mm. Window style should be easy to operate. Window should have wider sills for safety.
	Window handle height should be 1200mm and 1010mm in wheelchairs design.
	Window handle style should be lever handles or d type. The cranks type should be avoided.
	Curtains should be provided at the windows to protect from direct sunlight that can adversely affect the level of lighting and/or reflected glare.
Control units	Switch height should be 1200 mm for independent, 1000 mm for cane required, and 900 mm for wheelchair required.
	Switch style should be push-button and should have color coded and / or shape coded to distinguish the on and off power.
	Socket height should be between 500mm and 1200mm for independent, 500mm and cane required and 500mm and 900mm for wheelchair required.
	The plug should have a graspable surface, and the wire should project downward or to the side and should have a different color from the outlet.
Environment	Mirror should be provided at maximum of 1650mm. In wheelchair design, a full-length mirror should be provided with maximum of 1350mm in height.
	The basic lighting in the bedroom should be 150 lux in the evening while in the night times when the elderly go to bed, it should be reduced to 50 lux.
	Floor colors should have contrast colors with the wall. Floor should be use non-slippery material; matte finish material is more recommended. Walls should have yellow color because the elderly can see it more easily.
	In the cane required design, clear space 900mm is needed while in wheelchairs required design, clear space 1500mm x 1500mm is needed to make a 360° wheelchairs turning.

5(b). If in the bedroom using shelves then the recommended dimensions should be maximum of 1400mm and minimum of 300mm in height for independent and cane required design. While, in the wheelchairs required design, it should be maximum of 1200mm and minimum of 405mm. Shelves edges or corners should be rounded. The plug should have a graspable surface, and the wire should project downward or to the side and should have a different color from the outlet.

Figure 6 presents the guideline designs of bed and window area (right side and back side position of the bedroom). The height of the window handle should not be too high or too low so that all types of elderly people can reach it. Window also should have wider sills for safety reason. Bed height should be 380mm to accommodate independent and cane required elderly. The low enough bed will facilitate the elderly to stand up from the bed easily. While in wheelchair design, bed height should be 500 mm because it should have the same height as the wheelchairs so that the elderly can transfer from the wheelchairs to the bed easily.

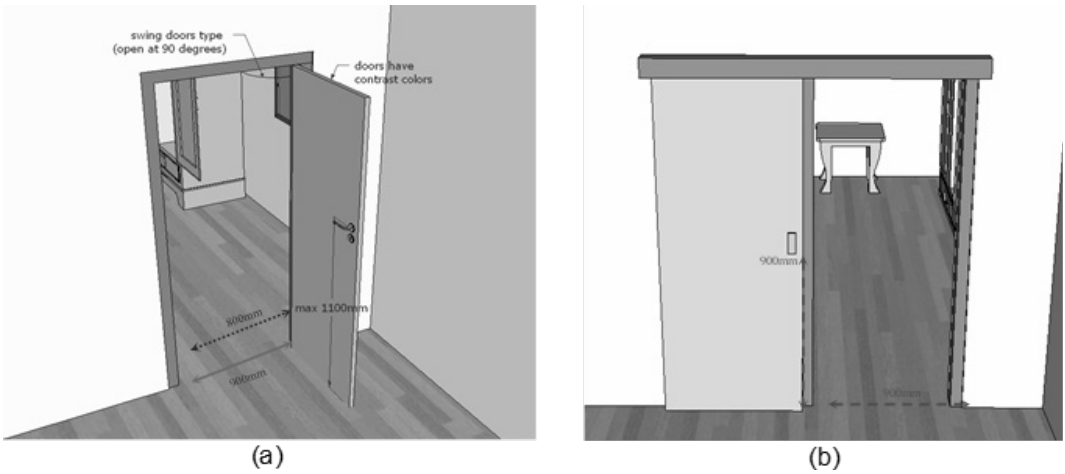

Figure 4. Guideline design of entrance.

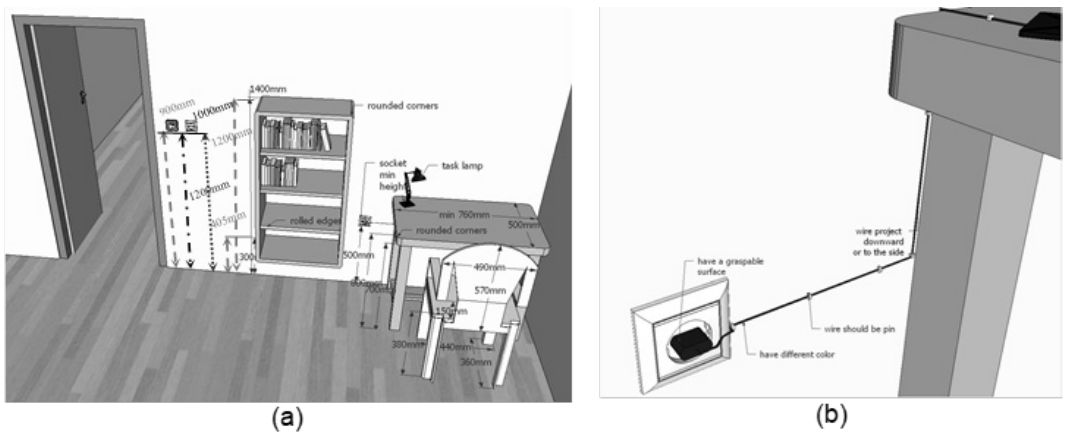

Figure 5. Guideline design of elderly bedroom (front side).

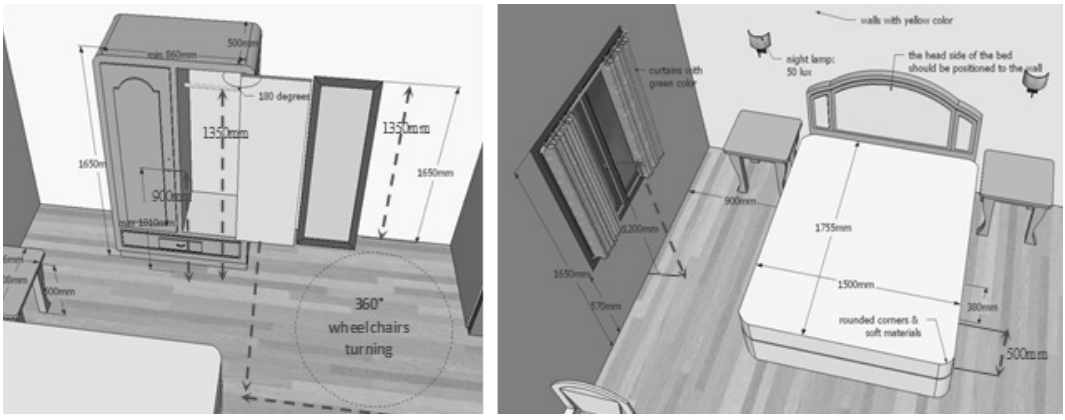

Figure 6. Guideline design of elderly bedroom (right side and back side).

Conclusion

In response to the older adults' desires who prefer to remain in their current residence, it is important to design a safe and comfortable house facilities for them. Therefore, this study evaluated the elderly bedroom facilities by considering human factor principles. The elderly in this study divided into three subgroups: independent, cane required, and wheelchairs required. The evaluation ratings were conducted by using 5 points

score. The result showed that the respondent 1 has a more supportive bedroom design for the elderly compared to the others. However, the bedroom design of respondent 1 still need improvement in several items. As a comparison the 3D picture of current design and proposed design of each elderly group were presented. In the end, this study proposed guidelines to design appropriate bedrooms for older adults.

In future studies, the number of bedroom observed can be added. Elderly groups can also be extended by considering elderly with dementia and Alzheimer's in design. It would be more interesting to compare bedroom design in different country.

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