A Readiness of Areas and Space Planning in Houses Supporting Emergency Services for Fall Injuries in The Elderly

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Abstract. The global population structure is currently stepping into an aging society. In the change of the world population structure, critical care of older adults from fall injuries at home is a major public health issue since the falls can lead to disability or death. By reviewing the architectural design research, most studies focus on the design approaches aiming to reduce the risk of fall accidents occurred among the elderly. However, no study has investigated the correlation of architectural design in supporting the medical care of seniors after slip and fall accidents. Therefore, this research aims to evaluate area and space planning of typical three single houses supporting emergency medical care for falling accidents amongst the elderly. The study firstly investigates the activities and the area required for the medical operation by interviewing medical specialists and rescue teams from two hospitals and two related agencies. Then, the activities and area requirements are mapped with the room layout of three typical single houses located in the Bangkok neighborhood areas. It is found that the designed layout and room area of all studied houses inadequately supports for emergency situations, which has only two available areas from a total of thirteen areas. The details of the space availability and obstacles for emergency medical care are discussed and proposed for improving the space planning and layout of the house for future work.

1. Introduction
The continued growth of the older population increases the possibility of the elderly living alone in their homes and risk from fall accidents [1]. Falls in the elderly are a significant cause of accidental or unintentional injury deaths. Several organizations related to public health, especially the World Health Organization (WHO), Centre of Disease Control and Prevention (CDC) and National Council of Aging (NCOA), have investigated variable risk factors for the falls and proposed effective prevention strategies to prevent and reduce the risk of older adult’s falls. Furthermore, many studies have comprehensively studied fall prevention by educating on self-care skills [2], arranging the home environment and providing necessary equipment [3]. At present, Artificial Intelligence (AI) and robots have been developed for elderly care [4-5]. According to the reviews, most studies focus on the strategies preventing falls in older adults. However, there is a research gap on the oversight of the procedure after the fall accidents occur.
Emergency medical service is essential and significant to save elders from falling and injuring themselves in their homes [6]. The process requires rapid access to treat the patients and ensure comfortable operational space for medical care. In consideration to house plans, the design mainly focuses on its intended function or purpose. However, the operational space for emergency medical care on-site is possibly exclude in the initial design. When fall accidents occur, inadequate layout planning could delay access to healthcare services in houses. This study aims to investigate area requirements for on-site medical care for older adult falls together with the evaluation of the room layout of typical single houses in Thailand that can support the emergency medical services (EMS) to help older adults from falls. The study’s findings could provide barriers and limitations of designed space for the operation of medical treatment in Thai houses. Therefore, recommended design and further investigations are proposed.

2. Methodology
The study calculates area requirement and space for rescue staff, response kits, lifting, and the handling of equipment to help older adults who have fallen in their homes. These required rescue area and space is then mapped in the first-floor plan of the studied houses to assess the available space for on-site medical care. The procedure of moving the elderly to an ambulance is not accounted for in this study.

Medical specialists and rescue teams from four organizations were interviewed, including professionals working in Siriraj Hospital, Chulabhorn Hospital, the Ruamkatanyu rescue team, and the First Ambulance team. The questions for the interview include the following: How many staff work for on-site services?; What rescue kits and equipment, including its dimension, are used during on-site medical care?; What activities they do during the treatment of older adults who have fallen? These activities and suggested required equipment from the interview are later used to define the dimension and area of on-site medical care. According to the interview, the devices used for safe and proper relocation of patients into the ambulance comprises of stretcher cots, long spinal boards, stair chairs, and scoop stretchers. During the treatment, the medical team practically utilizes a long spinal board as a first aid and evacuation tool while the emergency bag and accessories are integral for medical treatment. In this study, the area required for the on-site emergency service is calculated based on the performance of medical treatment with the long spinal board since this device requires a larger service area than other devices. The length of the board is 1.85 m in length and 0.45 m in width. Figure 1 presents the area requirement and dimension for on-site medical care. It is assumed that three medical staff is carrying the patient on both sides of the long spinal board. As a consequence, the on-site medical care with a long spinal board requires a minimum area of 7.06 m² with a width of 2.05 m, and 3.45 m in length.

Previous study [7] investigated and classified design characteristics and building floor plans of Thai single-detached houses located in neighborhood areas in Bangkok. This study selects three models of single-detached houses, which accounts for a large portion of Thailand’s housing stock. It is defined that the studied houses have a bedroom for older adults living on the first floor. The areas that the falls are likely to occur in the house comprises of the bedroom (1), toilet (2), stair (3), corridor 1 (4), corridor 2 (5), living area (6), dining area 1 (7), dining area 2 (8), pantry (9), kitchen (10), washing area (11), terrace (12), and parking (13).

In this study, the minimum area requirement for on-site medical care is mapped in the thirteen studied areas of the three-building case studies. The area sufficiently supporting the on-site medical service is marked and compared. The obstacles, obstruction, and barriers within the space for the medical service are then identified and proposed and noted as references for improvement in future projects.
3. Results and Discussion

Figure 2 presents the mapped house’s floor plan with the area requirement for on-site medical care. The rectangular shape with the red highlight represents insufficient space for on-site medical care, while those with the green highlight can support the medical service (figure 2(1)). Figure 2(2) shows the locations and types of barrier for the medical service in the studied areas. Overall, the area of the kitchen, bedroom, stair, and toilet is relatively small. Even the area is larger than that requirement, the perimeter of this area is inadequate for that operation. The walls are a significant barrier for taking care of such small rooms, whereas the obstruction for the on-site medical care in dining and living areas mostly are the arrangement of heavy and built-in furniture. In House A, it is found that the obstacles include 17 furnitures (F1, marked as the yellow circle) (mobile furniture such as chairs is not counted), 11 indoor walls (W1, marked as the red circle), and 14 outdoor walls (W2, marked as the green circle). For House B, the obstacles comprise 16 furniture (F1), 11 indoor walls (W1), and 17 outdoor walls (W2). House C has many obstacles but fewer than those found in House A and B, in which the obstacles include 15 furniture (F1), 9 indoor walls (W1), and 16 outdoor walls (W2).

Table 1 presents a score calculation of available areas that can correspond to the on-site medical care weighted by thirteen studied areas. Overall, all studied houses have available space supporting on-site medical care for only 2 areas from a total of 13 areas, which accounts for 15 percent. One of those areas found in all three houses is car parking. The interior space is adequate for the medical care for House A and B, then it is the corridor and dining area, respectively. For House C, all available areas are outdoors, including car parking and outdoor terrace.

In comparison to adequate space for medical care and first aid in the three studied houses. It is found that House A and B is stronger in readiness for emergency situations than that of House C. It is because these two houses have medical care area in interior space, whereas both spaces of House C are located outdoor. Overall, the design of room layout and areas of the typical single houses in Thailand are not sufficiently supported the on-site emergency medical service. These barriers could delay access to medical treatment for older adult’s injuries on site, which leads to serious health effects and reduces the quality of life.

Figure 1. The size of equipment, dimension and area requirement for the medical care activities.
Figure 2. (1) Presents the mapping of medical care areas in different locations on the 1st floor of three houses for this case study. (2) Depicts the obstacles and barriers for medical care.

Table 1. Available the medical care area scoring

| No. | Area            | Available area supporting the on-site medical care | House A | House B | House C |
|-----|-----------------|-----------------------------------------------------|---------|---------|---------|
|     |                 |                                                     | m²a     | %b      | m²a     | %b      | m²a     | %b      |
| Indoor |                 |                                                     | Score   |         | Score   |         | Score   |         |
| 1    | Bedroom         |                                                     | 2.71    | 38%     | 0       | 4.31    | 61%     | 0       |
| 2    | Toilet          |                                                     | 2.21    | 31%     | 0       | 2.25    | 32%     | 0       |
| 3    | Stair           |                                                     | 2.11    | 30%     | 0       | 2.07    | 29%     | 0       |
| 4    | Corridor 1      |                                                     | 4.32    | 61%     | 0       | 2.54    | 36%     | 0       |
| 5    | Corridor 2      |                                                     | 7.06    | 100%    | 1       | 5.50    | 78%     | 0       |
| 6    | Living area     |                                                     | 6.11    | 87%     | 0       | 5.85    | 83%     | 0       |
| 7    | Dining area 1   |                                                     | 6.30    | 89%     | 0       | 7.06    | 100%    | 1       |
| 8    | Dining area 2   |                                                     | 3.79    | 54%     | 0       | 4.65    | 66%     | 0       |
| 9    | Pantry          |                                                     | 3.49    | 49%     | 0       | 3.83    | 54%     | 0       |
| 10   | Kitchen         |                                                     | 3.55    | 50%     | 0       | 3.80    | 54%     | 0       |
| Outdoor |                 |                                                     |         |         |         |         |         |         |
| 11   | Washing area    |                                                     | 6.89    | 98%     | 0       | 3.83    | 54%     | 0       |
| 12   | Terrace         |                                                     | 4.75    | 67%     | 0       | 3.41    | 48%     | 0       |
| 13   | Car parking     |                                                     | 7.06    | 100%    | 1       | 7.06    | 100%    | 1       |
| Total indoor pts. |                             |                                                     | 1 (8%)  |         | 1 (8%)  |         | 0 (0%)  |         |
| Total outdoor pts. |                             |                                                     | 1 (8%)  |         | 1 (8%)  |         | 2 (15%) |         |
| Total pts. |                             |                                                     | 2 (15%) |         | 2 (15%) |         | 2 (15%) |         |

a is an available area (empty space).

b is a percentage of available area weight by the minimum area requirement for on-site medical care.
4. Conclusion
This study evaluates the design of room layout and areas of typical single houses in Thailand that can support Emergency Medical Services to aid the elderly having fall injuries in the house. The on-site medical service and evacuation devices are gathered by the interview of medical specialists and rescue teams. These collected data are used to calculate the area required for the medical treatment operated by three medical staff proceeding their tasks along the perimeter of the long spinal board. Such a minimum area requirement is then mapped and evaluated with the floor plan of three single houses, commonly found in neighborhood districts in Bangkok. It is found that the designed layout and room area of all studied houses insufficiently support the medical treatment on site, which has only two available areas. One of those is outdoor car parking. Considering safety for indoor living environment, House A and B provide more comfortable space (founded in the dining area and indoor corridor) for on-site medical treatment than that of House C. For future studies, the flexible design for interior walls and the arrangement of mobile and innovative furniture in the interior of residences providing the medical care in the houses should be further explored. Emergency Medical Services underlies several processes, in which one significant part is an evacuation of the patient into the ambulance. Instead of the medical treatment on site, future studies should examine whether the space allowing circulation and evacuation permits rapid movements in the urgent case of necessary transportation the seniors in their houses. Ultimately, these studies serve as crucial guidance in reducing the risk of fall injuries in the elderly in the houses.

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