

Calculation of Number of Residents by Floor Placement of Elderly Medical Welfare Facilities Using Pathfinder

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Abstract: In this study, the number of residents by floor placement of the elderly medical welfare facility was calculated using Pathfinder program. The first scenario showed that adequate number of residents by floor placement is less than 25. The second scenario showed that showed that adequate number of residents by floor placement is less than 24. The third scenario showed that showed that adequate number of residents by floor placement is less than 27. The fourth scenario showed that showed that adequate number of residents by floor placement is less than 27. Overall, evacuation process is faster when staff are placed on the higher floor rather than first floor, and when male residents are placed on the lower floor than female residents. Henceforth, more research is needed to study the evacuation time in relation to fire extinguishing facility operation and to study the evacuation time when there is a visual field defect due to smoke and fire.

Keywords: Elderly Medical Welfare Facility, Residents, Staff, Floor placement, Pathfinder

1. Introduction

Korea is a rapidly aging society. Along with rapid aging, the number of facilities for the elderly is increasing. Surveying the event of fire in facilities for elderly and children in 2020, there were 32 events in facilities for elderly, adding up to 33 events when including the facilities for the disabled which the resident characteristics are similar, which is 31.13% of entire events of fire.[A] Also, the Gyeongnam Miryang Sejong hospital fire on January 26th, 2018 had majority of resident dead out of around 100 residents, and most of the casualty were bedridden elderly.[B] If an elderly medical welfare facility where most of the residents are immobile lacks coping capacity, the bedridden elderly who always need care worker can be the most fragile victim in case of major accidents.

Previous studies conducted by Hong Hae-Ri et al. (2016) [C] investigated on the sense of safety of facility workers to secure the evacuation safety of disaster vulnerable person. A study conducted by Cha Jong-Ho (2017) [D] researched a method to reduce the casualty with smoke controlling method using air curtain considering the patients who can evacuate on their own. A study conducted by Kim Hyeon-Woo et al. (2019) [E] found an institutional alternative to enable bedridden patients to evacuate safely during the event of fire. A study conducted by Kim Yoon-Jeong et al. (2009) [F] designed an evacuation plan by studying the systematic situation and problem on the basis of fire and evacuation on the elderly medical welfare facility.

Most of the previous studies contemplated on how to shorten the evacuation time. There is rarely a study that calculated evacuation time by setting floor placement of residents and staff as a major variable.

Thus, this study aims to evaluate the efficiency and floor placement and evacuation safety by analysing the result of placing residents and staff in each floor using Pathfinder.

2. Floor Placement of Elderly Medical Welfare Facility

In the elderly medical welfare facility, there is the director to manage the overall facility and staff, doctors and nurse aides to take care of residents' health, physical therapists for rehabilitation treatment of residents, social workers to resolve problems of residents, care workers who manage resident care, nutritionist to provide healthy diet to residents, cook who prepares meal for residents, and hygiene worker to clean the room and do laundry for residents. Also, to enable easier management of the facility and residents and to let visitors' visit easier, director's office, dispensary, office, cafeteria and night-duty room is placed on the first floor. And above the first floor, male resident's room and female resident's room are placed separately.

The facility that was used in this study is a senior medical welfare facility located at XX city, XXX province. The building has 3 stories above ground and 1 underground level. The first floor is occupied by staff, and second and third floor is the ward.

Figure.1 Floor plan – 1st floor

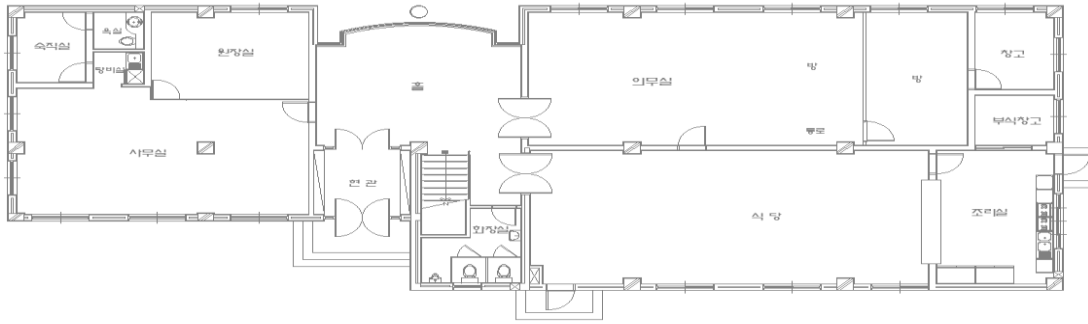
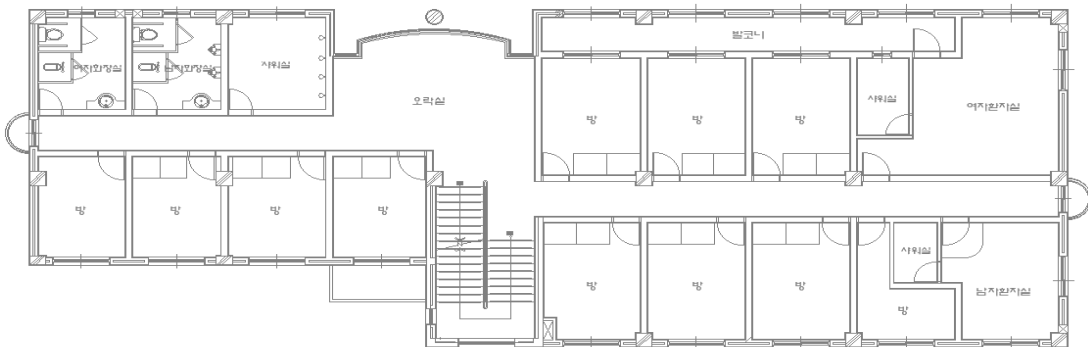


Fig.2 is the floor plan of second floor, which has bathroom, female patients' room and male patients' room. Rooms are separated by gender. Immobile residents are placed in female patients' room and male patients' room. The floor placement is safe on the second and third floor.

Figure.2 Floor plan – 2nd, 3rd floor



3. Input Value

3.1. Calculation of Number of Residents

Assuming there are 48 residents, there are total 30 staff : 1 director, 1 social worker, 1 doctor, 2 nurse or nurse aides, and 20 care workers(1 care worker per 2.5 residents), and 2 cooks. The calculation basis is described in the Table 1.

Table.1. Calculation of number of staff [G]

	Placement basis	Number of staff
Director		1
Social worker	1 per 30 residents or higher	1
Doctor		1
Nurse or Nurse aide	1 per 25 residents	50/25 = 2
Physical therapist or occupational therapist	1 per 30 residents or higher	1
Care worker	1 per 2.5 residents	50/2.5 = 20

Nutritionist	1 per 30 residents or higher	1
Cook	1 per 25 residents	$50/25 = 2$
hygiene worker	1 per 30 residents or higher	1
Total		30

3.1.2. Physical and behavioral characteristics of staff

This was created based on 'Korean body size' published by NSO through age and gender. [H][I]

The walking speed of staff is applied with healthy person's walking speed who is familiar with building's structure and route [J], and the walking speed of residents referred to study by Yoo Hui-Kwon et al. (2003) [K], and Kim Eung-Sik et al. (2016) [L].

Also, to help residents who cannot evacuate on their own, an Assisted Evacuation team was designed. The team consist of doctor, nurse, nurse aide, social worker, and care worker. The behavioural characteristics of director and cook is 'Self-evacuation' which they evacuate independently.

Table.2. Physical and behavioral characteristics of staff

	Gender	Height (cm)	Shoulder width (cm)	Walking speed(m/s)	Behavioural characteristics
Director	F	157	35.9	1.2	Self-evacuation
Doctor	M	173.7	40.3	1.2	Assisted Evacuation team
Nurse aide	F	156	35.9	1.2	Assisted Evacuation team
Physical therapist	M	173.7	40.3	1.2	Assisted Evacuation team
Social worker	F	156	35.9	1.2	Assisted Evacuation team
Care worker	F	157	35.9	1.2	Assisted Evacuation team
Nutritionist	F	156	35.9	1.2	Self-evacuation
Cook	F	155.5	35.9	1.2	Self-evacuation
Hygiene worker	F	155.5	35.9	1.2	Self-evacuation

4. Scenario Composition

4.1. Scenario 1: Staff on 1st floor, Male residents on 2nd floor, Female residents on 3rd floor

After placing the staff on the first floor, male residents on the second floor and female residents on the third floor, the study ran a simulation to analyse if the residents can evacuate within available evacuation time and apprehend the evacuation time.

4.2. Scenario 2: Staff on 1st floor, Female residents on 2nd floor, Male residents on 3rd floor

After placing the staff on the first floor, female residents on the second floor and male residents on the third floor, the study ran a simulation to analyse if the residents can evacuate within available evacuation time and apprehend the evacuation time

4.3. Scenario 1: Male residents on 1st floor, Female residents on 2nd floor, Staff on 3rd floor

After placing the male residents on the first floor, female residents on the second floor and staff on the third floor, the study ran a simulation to analyse if the residents can evacuate within available evacuation time and apprehend the evacuation time.

4.4. Scenario 1: Female residents on 1st floor, Male residents on 2nd floor, Staff on 3rd floor

After placing the female residents on the first floor, male residents on the second floor and staff on the third floor, the study ran a simulation to analyse if the residents can evacuate within available evacuation time and apprehend the evacuation time.

5. Conclusion and Consideration on Available Evacuation Time

Considering that the facility in this study is an elderly medical welfare facility, the study calculated available evacuation time as less than 5 minute assuming that announcement warnings are provided along with trained staff during day time.[13] Considering the delay in evacuation starting time regarding the age of residents during day time, the study set evacuation starting time as 60 seconds after the start of fire. Table 4 indicates the available evacuation time of residents.

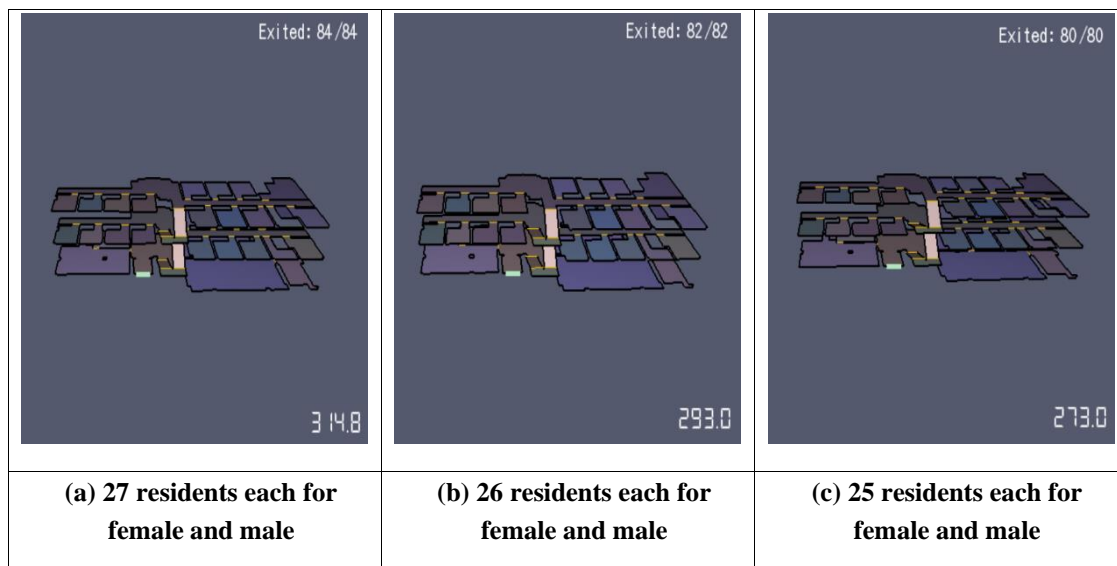
. **Table.4.** Available Evacuation Time of Residents

Building purpose	Available evacuation time
Hospital, nursing home, and public accommodation (Most of residents require help)	Less than 5 minutes

5.1. Adequate number of residents from floor placement by Scenario 1

The study calculated adequate number of residents from floor placement by scenario 1, and it took 314.8 seconds when there were 27 male and 27 female residents, 293.0 seconds when there were 26 male and 26 female residents, 273.0 seconds when there were 25 male and 25 female residents, and 266.3 seconds when there were 24 male and 24 female residents. Fig.3 indicates the evacuation simulation result to calculate adequate number of residents from floor placement by scenario 1.

Figure 3. Evacuation time by Scenario 1



The shortest evacuation time was when there were 25 male and 25 female residents, and when there were 27 male and 27 female residents, the evacuation time was over 300 seconds. Thus, the adequate number of residents from floor placement by scenario 1 is 25 male and 25 female patients so that the evacuation is completed within available evacuation time. Table 5 summarized the adequate number of residents from floor placement by scenario 1.

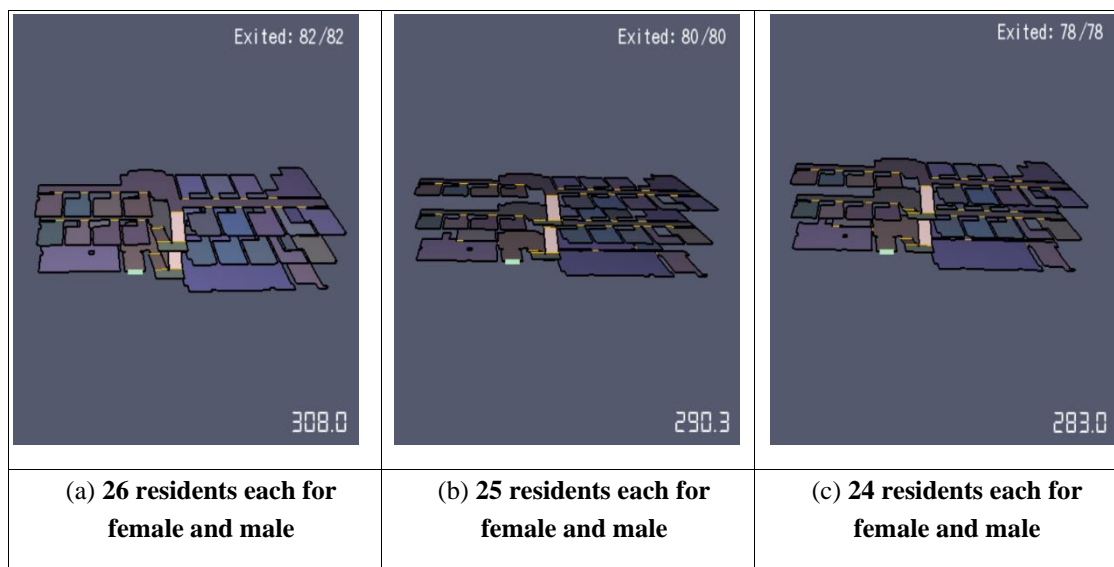
Table.5. Adequate number of residents by Scenario 1

Male Residents	Female Residents	All Residents	Evacuation Time
27	27	54	314.8
26	26	52	293.0
25	25	50	273.0

5.2. Adequate number of residents from floor placement by Scenario 1

The study calculated adequate number of residents from floor placement by scenario 2, and it took 208.0 seconds when there were 26 male and 26 female residents, 290.3 seconds when there were 25 male and 25 female residents, and 283.0 seconds when there were 24 male and 24 female resident. Fig.4 indicates the evacuation simulation result to calculate adequate number of residents from floor placement by scenario 2.

Figure 4. Evacuation time by Scenario 2



The shortest evacuation time was when there were 24 male and 24 female residents, and when there were 26 male and 26 female residents, the evacuation time was over 300 seconds. Thus, the adequate number of residents from floor placement by scenario 2 is 24 male and 24 female patients so that the evacuation is completed within available evacuation time. Table 6 summarized the adequate number of residents from floor placement by scenario 2.

Table 6. Adequate number of residents by Scenario 2

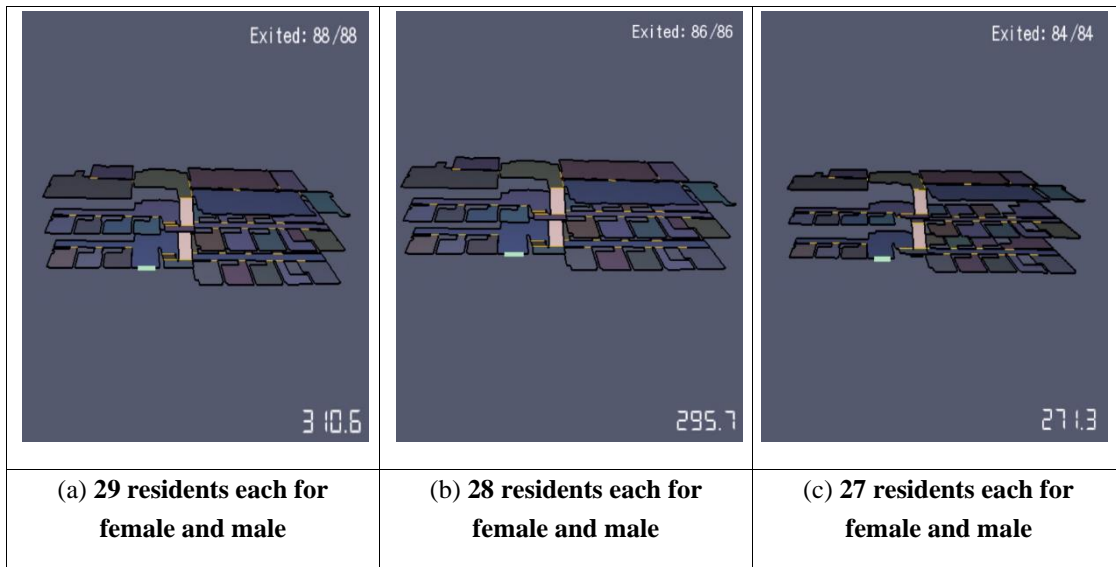
Male Residents	Female Residents	All Residents	Evacuation Time(s)
26	26	52	308.0
25	25	50	290.3

24	24	48	283.0
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5.3. Adequate number of residents from floor placement by scenario 3

The study calculated adequate number of residents from floor placement by scenario 3, and it took 310.6 seconds when there were 29 male and 29 female residents, 295.7 seconds when there were 28 male and 28 female residents, 271.3 seconds when there were 27 male and 27 female residents, and 267.2 resident. Fig.5 indicates the evacuation simulation result to calculate adequate number of residents from floor placement by scenario 3.

Figure 5. Evacuation time by Scenario 3



The shortest evacuation time was when there were 27 male and 27 female residents, and when there were 29 male and 29 female residents, the evacuation time was over 300 seconds. Thus, the adequate number of residents from floor placement by scenario 3 is 28 male and 27 female patients so that the evacuation is completed within available evacuation time. Table 7 summarized the adequate number of residents from floor placement by scenario 3.

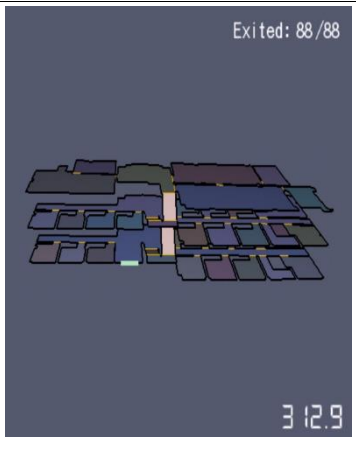
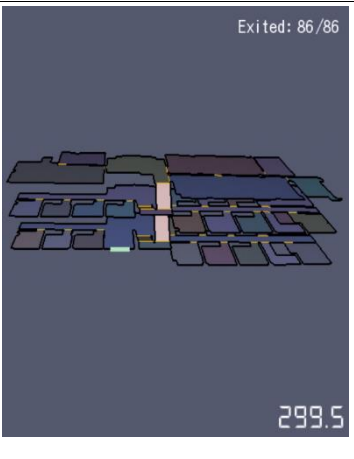
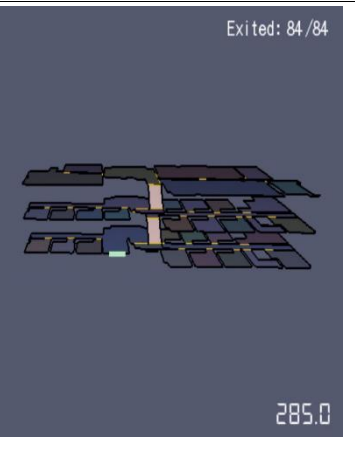
Table 7. Adequate number of residents by Scenario 3

Male Residents	Female Residents	All Residents	Evacuation Time(s)
29	29	58	310.6
28	28	56	295.7
27	27	54	271.3

5.4. Adequate number of residents from floor placement by scenario 4

The study calculated adequate number of residents from floor placement by scenario 4, and it took 312.9 seconds when there were 29 male and 29 female residents, 299.5 seconds when there were 28 male and 28 female residents, 285.0 seconds when there were 27 male and 27 female residents. Fig.6 indicates the evacuation simulation result to calculate adequate number of residents from floor placement by scenario 4.

Figure 6. Evacuation time by Scenario 4

		
<p>(a) 29 residents each for female and male</p>	<p>(b) 28 residents each for female and male</p>	<p>(c) 27 residents each for female and male</p>

The shortest evacuation time was when there were 27 male and 27 female residents, and when there were 29 male and 29 female residents, the evacuation time was over 300 seconds. Thus, the adequate number of residents from floor placement by scenario 3 is 28 male and 27 female patients so that the evacuation is completed within available evacuation time. Table 8 summarized the adequate number of residents from floor placement by scenario 4.

Table 8. Adequate number of residents by Scenario 4

Male Residents	Female Residents	All Residents	Evacuation Time(s)
29	29	58	312.9
28	28	56	299.5
27	27	54	285.0

6. Conclusion

This study calculated the adequate number of residents by floor placement of elderly medical welfare facility using Pathfinder program.

The adequate number of male and female residents from floor placement by scenario 1 was 27 each when it took 314.8 seconds, 26 each when it took 293.0 seconds, 25 each when it to 273.0 seconds. Thus, the adequate number of residents in scenario 1 was 26 male and 26 female residents or less.

The adequate number of male and female residents from floor placement by scenario 2 was 27 each when it took 329.0 seconds, 26 each when it took 308.0 seconds, 25 each when it to 290.3 seconds. Thus, the adequate number of residents in scenario 2 was 25 male and 25 female residents or less.

The adequate number of male and female residents from floor placement by scenario 3 was 29 each when it took 310.6 seconds, 26 each when it took 295.7 seconds, 25 each when it to 271.3 seconds. Thus, the adequate number of residents in scenario 3 was 27 male and 27 female residents or less.

The adequate number of male and female residents from floor placement by scenario 4 was 29 each when it took 312.9 seconds, 28 each when it took 299.5 seconds, 27 each when it to 280.5 seconds. Thus, the adequate number of residents in scenario 4 was 28 male and 27 female residents or less.

In conclusion, it was confirmed that placing staff on the first floor than higher floor, and placing male residents in lower floor than female residents had shorter evacuation time. This study is limited as it excluded comparative analysis. This study is limited as it excluded comparative analysis on the situation where fire extinguishing facility

such as sprinkler operates. In the future, there is a need to conduct a study about the evacuation time in accordance with the operation of fire extinguishing facility, and the evacuation time when there is a visual field defect due to smoke and fire.

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