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Research Article

Calculation of Number of Staff for Safe Evacuation in Elderly Medical Welfare Facilities

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Abstract: In this study, the adequate number of staff that need to be allocated for evacuation of entire residents during daytime and night time through Pathfinder program. The adequate number of staff working for day and night shift were calculated in accordance with available evacuation time, fire brigade arrival time, and flashover occurrence time. As the result, when there are 48 residents, the adequate number of day shift staff for each evacuation time was 10 staff for 300 seconds, 5 staff for 430 seconds, and 4 staff for 540 seconds. As for the night time, considering there is fewer working staff, when there are 48 residents, the adequate number of night shift staff for each evacuation time was 13 staff for 430 seconds, 7 staff for 480 seconds, 6 staff for 540 seconds. In conclusion, 10 stationed day shift staff, and 6 stationed night shift staff is the adequate condition for safe evacuation. Henceforth, more researches regarding the evacuation time regarding the operation of firefighting facilities are needed.

Keywords: Elderly medical welfare facility, staffing standards, adequacy, day shift staff, night shift staff

1. Introduction

According to senior population in Korean for recent 3 years, it has been increasing year on year.[A] The increase rate was 14.8% on December 2018, 15.5% on December 2019, and 16.4$ on December 2012. With the increase of senior population, the significance of facility for the elderly also rose, followed by increasing number of facilitie.[B] The more the facilities for the elderly are built, the more the accidents happen.

In 2019, XX Elderly medical welfare facility had fire, leaving 2 people dead and 46 people injured.[C] On the same year, XX Elderly medical welfare facility had fire, leaving 10 people inhaling smoke[D] and such dangerous accidents occur often to the elderly with mobility difficulties.

Previous study conducted by Jeon In-Beom et al (2018) [E] has calculated and proposed an evacuation time to check whether the actual evacuation on elderly medical welfare facility model is possible using FDS and Pathfinder. A study conducted by Park Hyeong-Ju et al (2018) [F] proposed a method extending ASET(available safe egress time) for bedridden elderly residing in elderly medical welfare facility, and a legislative regulation to reduce the placing time of evacuation aid staff. A study conducted by Cha Jong-Ho et al (2017) [G], it studied a method to reduce the casualty with smoke controlling method using air curtain considering the patients who can evacuate on their own.

Up to this date, most of the studies on evacuation at the elderly medical welfare facility calculated evacuation time to shorten then ASET or to decide the evacuation feasibility, and research the evacuation safety in accordance with the building structure.

This study aims to calculate the adequate number of day and night shift staff to enable entire evacuation of residents within ASET by using Pathfinder program.

2. Facility outline

The facility that was used in this study is a senior medical welfare facility located at XX city, XX 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. Fig.1 is the floor plan of first floor which has director's office, office, dispensary, cafeteria and storage. Fig.2 is the floor plan second floor, which has bathroom, female patients' room and male patients' room.

Figure.1 Floor plan – 1st floor

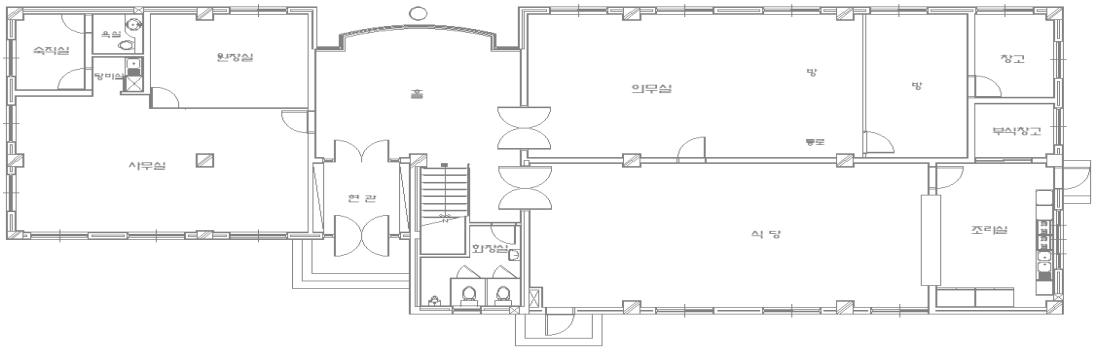
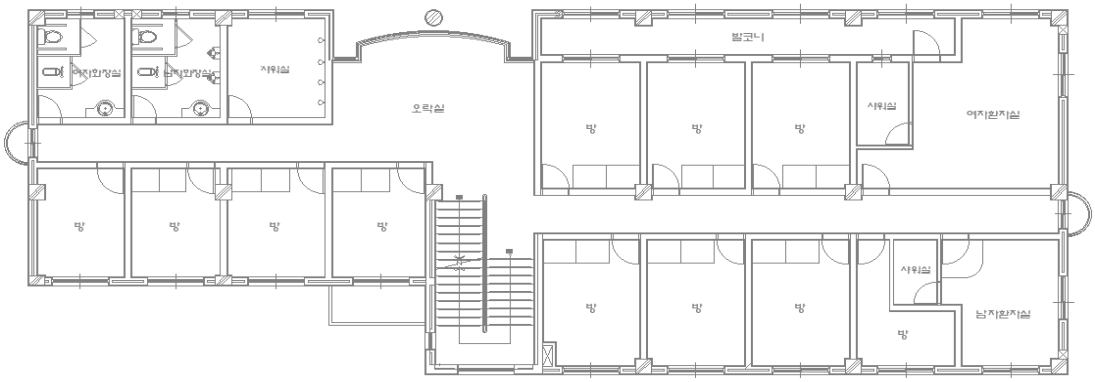


Figure. 2 Floor plan – 2nd, 3rd floor



3. Input Value

3.1. Calculation of number of residents

The area per 1 resident is bigger than 6.6 ㎡. Second and third floor has same structure, thus the maximum number of residents is 48 as Table 1.

Table.1. showing the percentage level of the awareness on the dietary habits among prospective teachers in Tirunelveli District**.**

Arrangement standard	Floor space(㎡)	Residents
1 resident per bed room area of 6.6 ㎡	314.2	48

3.2. Physical and behavioural characteristics of residents

As table 2 shows, the physical characteristics of resident are age, gender, height, shoulder width, and walking speed. This was created based on 'Korean body size' published by NSO through age and gender.[H][I] A study conducted by Kim Eung-Sik et al(2016) was used for walking speed. Residents from patients' room were categorized as non-residential patients. Doctors, nurses, nurses' aides were positioned on the first floor while residents were positioned on second and third floor.

The facility which is the target of this study has residents who lost mobility on their own, thus it is significant to understand the behavioral characteristics of residents' aides. This study as categorized residents as self-evacuator,

wheelchair user, and non-self-evacuator. Self-evacuator and wheelchair users have behavioral characteristics of self-evacuation, while non self-evacuators have behavioral characteristics of wait assisted evacuation team.

Table.2. Physical characteristics of residents

	Behavioural characteristics	Gender	Age	Height (cm)	Shoulder width (cm)	Walking speed(m/s)	Number of residents
Self-evacuator	Self-evacuation	M	Over 65	164.4	37.9	0.9	18
		F	Over 65	152.9	35.5	0.9	18
Non self-evacuator	Wait Assisted Evacuation team	M	Over 65	164.4	37.9	Bedridden (Immobile)	2
Self-evacuator	Self-evacuation					Wheelchair: 0.87	3
Non self-evacuator	Wait Assisted Evacuation team	F	Over 65	152.9	35.5	Bedridden (Immobile)	4
Self-evacuator	Self-evacuation					Wheelchair: 0.87	3
Total							48

4. Scenario composition and evaluation basis

4.1. Scenario composition

4.1.1. Caculation of staff during daytime evacuation

There are 48 residents in the facility used in this study. This study analysed the evacuation time in accordance with number of staff to calculate the adequate number of staff in accordance with available evacuation time, fire brigade arrival time and flash over occurrence time.

4.1.2. Caculation of staff during daytime evacuation

The study analysed the evacuation time in accordance with number of staff to calculate the adequate number of staff to enable entire evacuation within available evacuation time when there are small number of staff working during night time.

4.2. Evaluation Basis

4.2.1. 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 minutes assuming that announcement warnings are provided along with trained staff during day time.[J] However, as there are less number of staff during night time, the study calculated available evacuation time as less than 8 minutes assuming there is alert facility using fire alarm signal along with non-trained staff. 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, and for the night time, the study set evacuation starting time as 180 second after the start of fire considering the late acknowledgement of fire due to sleep, and difficulty of evacuation compared to day time. Table 3 indicates the available evacuation time for day and night time.

Table.3. Available Evacuation Time of Residents During Day and Night time

Building purpose	**Available evacuation time**	
	Day time	**Night time**
Hospital, nursing home, and public accommodation (Most of residents require help)	Less than 5 minutes	Less than 8 minutes

4.2.2. Fire Brigade Arrival Time

Average arrival time of Korean fire brigade is 7 minutes 10 seconds, and the firefighters arrive at the scene after the 911 call is average 7 minutes 10 seconds as of 2019, thus the study set the evacuation time as 7 minutes 10 seconds.[K] The fire site is the scene of race against the clock with life threatening dangers. Fire brigade arrival time is directly connected to golden time to save lives, so it is very important.

4.2.3. Flashover occurrence time

Flashover is the first step of fire growth. It is the phenomenon which the fire expands in a sudden due to ignition of inflammable gas.[L] Flashover happens as fast as 2~3 minutes, or take longer than 10 minutes. Assuming that the facility is fire safe considering the amount of inflammable objects, size and location of opening, size and height of building structure, interior material and furniture, the study set evacuation time as 9 minutes as the flashover occurrent might take 9 minutes from initial fire.[M]

5. Conclusion and Consideration

Staff is composed of director, doctor, nurse aide, physical therapist, social welfare worker, care worker, nutritionist, cook, and hygiene worker in accordance with「Enforcement Rules of the Elderly Medical Welfare Act」. Director, nutritionist, cook and hygiene worker are set as self-evacuation. Also, doctor, nurse aide, physical therapist, social welfare worker and care worker are set as assist evacuation team who can move helping the bedridden patients.

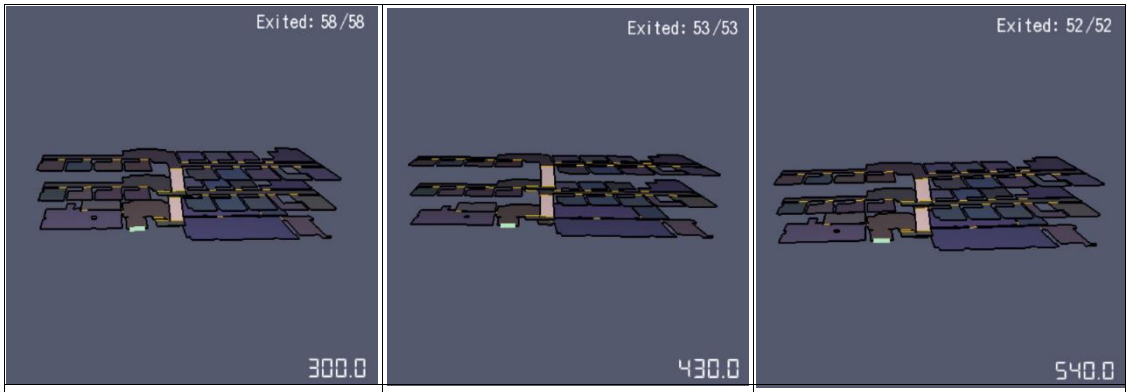
Considering the physical features of staff, the study set walking speed of director, care worker, nutritionist and hygiene worker as 1.3m/s and 1.5m/s for doctor, social welfare worker, nurse aide and physical therapist.

The population includes prospective teachers of Tirunelveli District. The investigators used simple random sampling technique and randomly selected 250 prospective teachers in Tirunelveli District.

5.1. Adequate number of day shift staff

Assuming there are 48 residents in the facility, the study calculated adequate number of day shift staff in accordance with available evacuation time, fire brigade arrival time, and flashover occurrence time. Fig 6 is the result of evacuation simulation that shows the adequate number of day shift staff.

Figure. 3 Adequate number of day shift staff



(a) Available Evacuation Time (300 seconds)	(b) Fire Brigade Arriva Time (430 seconds)	(c) Flashover Occurrence Time (540 seconds)

As the result of conducting evacuation simulation based on 30 day shift staff, entire 48 residents and 30 staff were evacuated after 292.5 seconds. This is less than available evacuation time (300 seconds). Also, the study reduced number of staff to improve efficacy, and as the result of apprehending number of staff that is available for evacuation, it was confirmed that 10 staff are needed to fit the available evacuation time (300 seconds), 5 staff are needed to fit the fire brigade arrival time (430 seconds), and 4 staff are needed to fit the flashover occurrence time(540 seconds). Table 4 indicates the different result of changed number of day shift staff by the time elapsed.

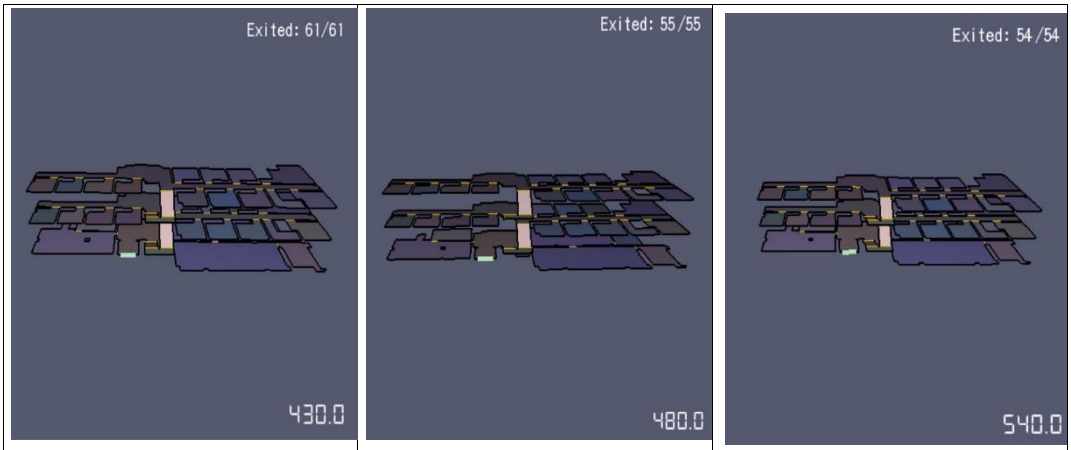
Table. 4 Adequate number of day shift staff in accordance with evaluation basis

Number of staff	Evacuation basis		
	Available Evacuation Time	Fire Brigade Arrival Time	Flashover Occurrence Time
3	44(86.27%)	45(88.23%)	46(90.19%)
4	45(86.53%)	49(94.23)	52(100%)
5	45(84.90%)	53(100%)	
10	58(100%)		

5.2. Adequate number of night shift staff

Considering there is less night shift staff working, the study calculated adequate number of day shift staff in accordance with available evacuation time, fire brigade arrival time, and flashover occurrence time assuming there are 48 residents in the facility. Fig 7 is the result of evacuation simulation that shows the adequate number of night shift staff.

Figure. 4 Adequate number of night shift staff



(a) Fire Brigade Arriva Time (430 seconds)	(b) Available Evacuation Time (480 seconds)	(c) Flashover Occurrence Time (540 seconds)

As the result of conducting evacuation simulation to figure out the number of staff needed to enable evacuation of residents within available evacuation time, 13 staff are needed to fit Korean fire brigade arrival time (430 seconds), 7 staff are needed to fit available evacuation time(480 seconds), and 6 staff are needed to fit flashover occurrence time(540 seconds). Table 5 indicates the different result of changed number of night shift staff by the time elapsed.

Table. 5 Adequate number of night shift staff in accordance with evaluation basis

Number of staff	Number of evacuees per time elapsed		
	Fire Brigade Arrival Time	Available Evacuation Time	Flashover Occurrence Time
5	41(67.21)	47(77.04%)	50(94.33%)
6	45(83.33%)	48(88.88%)	54(100%)
7	52(89.65%)	55(100%)	
13	61(100%)		

6. Conclusion

This study calculated the adequate number of staff to enable the entire evacuation of residents during day and night time at the elderly medical welfare facility using Pathfinder program.

(1) The adequate number of day shift staff was calculated in accordance with available evacuation time, fire brigade arrival time and flashover occurrence time when there are 48 residents. As the result, the facility needs 10 staff to evacuate within available evacuation time, 5 staff for fire brigade arrival time, and 4 staff for flashover occurrence time. For the safe evacuation, at least 10 staff need to be stationed during daytime to evacuate within available evacuation time.

(2) The adequate number of night shift staff was calculated in accordance with available evacuation time, fire brigade arrival time and flashover occurrence time. As the result, the facility needs 13 staff to evacuate within fire brigade arrival time, 7 staff for available evacuation time, and 6 staff for flashover occurrence time. As available evacuation time during night is longer than fire brigade evacuation time, the standard time for safe evacuation should be fire brigade arrival time. Thus, at least 13 staff need to be stationed during night time to evacuate safely.

In conclusion, for safe evacuation, there is a need to station at least 10 staff during daytime, and at least 13 staff during night time. 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 evacuation time in accordance with the operation of fire extinguishing facility.

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