sustainability

MDPI

Article

The Enhancement of Fire Safety in Small-Scale Senior Citizen Welfare Institutions Based on Fire Protection Defense-in-Depth Strategy

Sung-Ming Hung [1,2], Shiuan-Cheng Wang [3], Shen-Wen Chien [4], Chung-Hwei Su [1,*] and Li-Peng Chen [2]

[1] Department of Safety, Health and Environmental Engineering, National Kaohsiung University of Science and Technology, Kaohsiung City 824005, Taiwan; 0415911@nkust.edu.tw
[2] Fire Bureau, Kaohsiung City Government, Kaohsiung City 806029, Taiwan; f108107104@nkust.edu.tw
[3] Department of Public Safety and Fire Science, Chia Nan University of Pharmacy and Science, Tainan City 717301, Taiwan; scwang@mail.cnu.edu.tw
[4] Department of Fire Science, Central Police University, Taoyuan City 333322, Taiwan; una179@mail.cpu.edu.tw
* Correspondence: such@nkust.edu.tw; Tel.: +886-7-601-1000 (ext. 37613)

Abstract: The number of elderly living in small-scale senior citizen welfare institutions in Taiwan has been increasing. Hence, enhancing the quality of care and safety of the residents in these institutions is a pressing issue. Our research team visited and reviewed data on 53 small-scale institutions in Tainan based on in-depth fire protection defense strategies and proposed a three-layer protection mechanism. The results showed that: (1) half (50%) of these institutions only meet the old anti-seismic system; (2) 26 (49%) institutions have multi-story buildings, thus, more staff needs to be arranged for night shifts to enable emergency responses on each floor; (3) all institutions have fire detectors; (4) 84% of the elderly living in these institutions are mobility-impaired and need to rely on the assistance of staff for evacuation; (5) most institutions (91%) employ foreign female caregivers which mostly work on night shifts; thus, routine training of emergency response should also consider the abilities of the foreign caregivers; (6) 35 (66%) institutions arrange only 50% of the day-shift manpower for the night shift; (7) 37 (70%) institutions should evaluate whether the function of their fire detectors is affected by fan air; and (8) 11 (21%) institutions use inflammable materials for furnishings to create a "cozy" atmosphere. This study also suggests that preventing smoke from spreading from a room that is on fire to other areas is an important evaluation item. Hopefully, these findings can serve as a reference for countries that are facing an increasingly aging population.

Keywords: fire protection defense-in-depth; small-scale senior citizen welfare institution; fire safety; egress; caregiver

Citation: Hung, S.-M.; Wang, S.-C.; Chien, S.-W.; Su, C.-H.; Chen, L.-P. The Enhancement of Fire Safety in Small-Scale Senior Citizen Welfare Institutions Based on Fire Protection Defense-in-Depth Strategy. *Sustainability* **2022**, *14*, 3196. https://doi.org/10.3390/su14063196

Academic Editor: Åsa Gren

Received: 18 January 2022
Accepted: 7 March 2022
Published: 9 March 2022

1. Research Motives

1.1. Population Aging in Taiwan

Taiwan has become an aging society [1,2] which is defined by the World Health Organization (WHO) as one having 7% of the total population over 65 years old. When the proportion reaches 14%, it is called an aged society; when the proportion increases to 20%, it is called a hyper-aged society [3]. In March 2019, the Statistics Department, under the Ministry of the Interior of Taiwan, released data indicating that the elderly population, of 65 years old or above, was 14%. Table 1 lists the elderly population in several different countries [4].

In Asia, the proportion of the elderly in Taiwan is only second to that in Japan and is close to that in South Korea. The proportion of the elderly population in Taiwan doubled from 7% to 14% over a span of 21 and half years, while the span was 24 years for Japan [5]. This shows that the population in Taiwan is rapidly aging. How to cope with an aging society is a pressing issue for many countries concerning the social welfare for the elderly, elderly care, elderly travel, and even crimes committed on the elderly [6–10].

Table 1. Proportion of population over 65 years old in several different countries.

Country	1980	2000	2020	2040 *
Taiwan	4.3 *	8.6	16.0	30.2
Japan	9.1	17.4	28.9	35.3
Korea	3.5	7.2	15.7	33.9
United States	11.3	12.4	16.9	21.6
United Kingdom	15.0	15.8	18.8	24.0
France	13.8	15.9	20.8	26.8

Unit: %. * Predicted values.

1.2. Fire Safety in Senior Citizens' Welfare Institutions

According to the statistics of Taiwan's Ministry of Health and Welfare in 2020, there has been only a slight increase in the number of senior citizen welfare institutions due to very stringent establishment requirements and regulations [11]. As a result, many institutions have existed for a long time. Figure 1 shows the number of institutions in the last six years. Figure 2 lists the number of residents living in those institutions. As more elderly are expected to move into existing senior citizen welfare institutions in the future, enhancing the quality of care and safety of residents is a pressing issue [12–14].

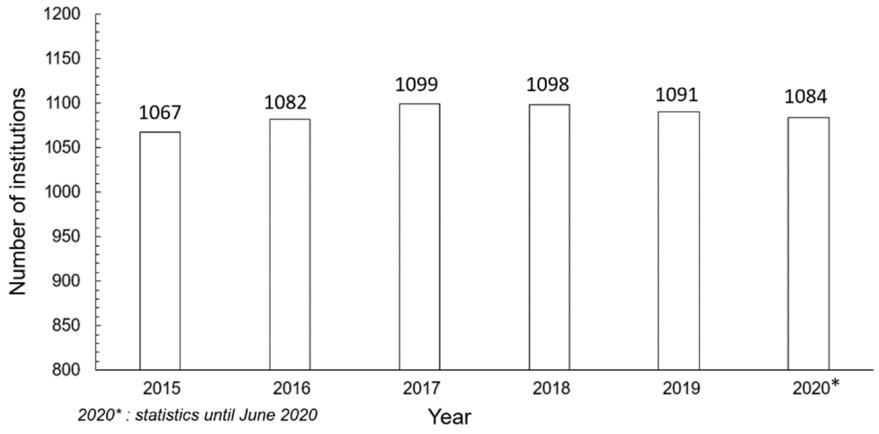


Figure 1. The number of elderly institutions in Taiwan in the last six years.

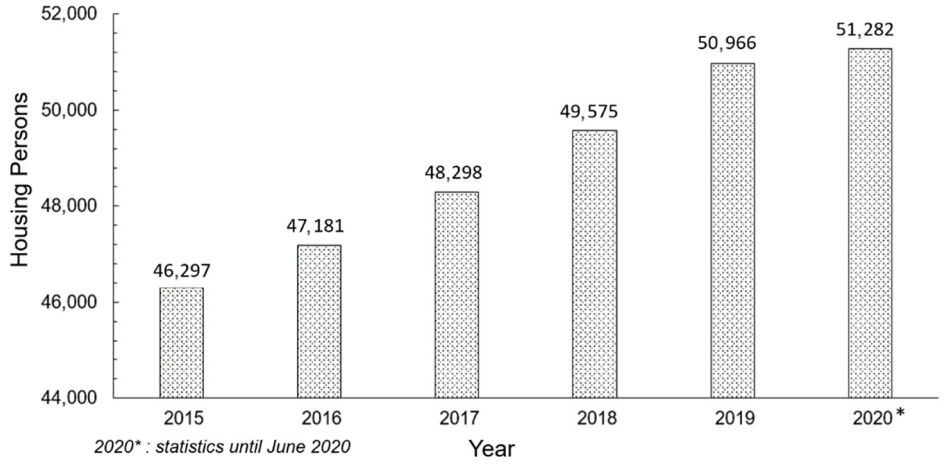


Figure 2. The number of people living in elderly institutions all day in Taiwan in the last six years.

In 2015, Folk et al. interviewed the senior staff of long-term care (LTC) institutions in Ottawa, Canada, and observed fire drills at three LTC institutions [15]. They thus developed a baseline for the current fire safety practices and procedures used by these facilities. Tseng et al. analyzed a solution for the "defense-in-place" policy and emergency response

strategy according to the characteristics of immobile patients [16]. The required safe egress time (RSET), including pre-movement time and travel time models, was compared with the available safe egress time (ASET) derived from the guidelines issued by the Architecture and Building Research Institute, Ministry of the Interior. The parameter ASET is the duration from the start of the fire to when people cannot be safely evacuated from the fire scene. The parameter RSET of the institution is the time required for the residents and staff in the institution to evacuate to a safe area after the fire, including the recognition time, pre-movement time, and movement time [17]. In small-scale senior citizen welfare institutions, some residents are unconscious and some take sleeping tablets at night, resulting in an infinitely long recognition time. For residents with inconvenient mobility or slow movement, pre-movement times and movement times will be infinite since their movement speeds are close to zero. Therefore, the values of RSET are much larger than the values of ASET. This explains why fire accidents in these institutions often result in serious casualties.

Many elderly have one or more chronic diseases, including hypertension, coronary artery disease, diabetes mellitus, cerebrovascular accident, chronic kidney disease, and congestive heart failure, which require regular medicine intake [18,19]. Fire safety in senior citizen welfare institutions is a serious concern. As some elderly who live in these institutions are mobility-impaired, heavy casualties are often reported in fire accidents at these institutions, arousing public concern. In recent years, several fire accidents occurred in hospitals and senior citizen welfare institutions in Taiwan. Table 2 lists the fire accidents with heavy casualties primarily attributable to smoke released by the fire [20].

Table 2. Fire cases in Taiwan's old welfare institutions in recent years.

Date	Case	Case Description
23 October 2012	Tainan City Beimen Nursing Home	• Fire location: Storage room • Reason: Man-made arson • Casualties: 13 dead and 59 minor and serious injuries
6 July 2016	New Taipei City Lohas Longevity Center	• Fire location: Ward on the 8th floor • Cause: Electrical appliances caught fire and ignited diapers • Casualties: 6 dead and 28 injured
10 March 2017	Taoyuan City Love Long-term Care Center	• Fire location: Second floor housing near the stairs • Reason: Candles ignited flammable materials • Casualties: 4 dead and 13 injured
19 May 2017	Pingtung County Nanmen Nursing Home	• Fire location: Housing 208 on the 2nd floor • Reason: Arson by residents • Casualties: 4 dead and 55 injured
13 August 2018	New Taipei City Nursing Home of Taipei Hospital established by the Ministry of Health and Welfare	• Fire location: Ward 7A23 • Cause: The power cord of a mattress caught fire • Casualties: 15 dead and 9 injured

1.3. Fire Prevention Needs in Senior Citizens' Welfare Institutions

Life-support and care services are interrupted when a fire accident occurs in a senior citizen welfare institution. The elderly that cannot evacuate themselves face threats in medical care and/or life safety. In Taiwan, building regulations and fire safety laws for senior citizen welfare institutions are similar to those for hospitals and even identical to those for public spaces [21,22]. Despite the government having proposed some special regulations, fire safety in senior citizen welfare institutions is governed by independent and stringent laws and regulations. For example, automatic sprinklers need to be installed regardless of the floor or area of the institutions.

Article 99-1 of Taiwan Building Technical Regulations was revised in 2013. It requires institutions to set up at least two fire compartments [23]. However, this requirement has not been enforced for institutions that were established before 2013. Although small-scale senior citizen welfare institutions comply with the old building and fire safety laws and regulations, they are still subject to some potential disasters as they only need to meet the basic requirements of the fire safety regulations. For the elderly with poor mobility, the fire safety requirements of the welfare institutions should be even higher. For example, regulations for fire and smoke compartments in buildings need to be more stringent. Institutions should be encouraged to install automatic fire extinguishing equipment rather than relying on manual firefighting. Fire alarm systems with automatic call-out functions should also be encouraged or even mandated.

Since most of the residents in small-scale senior citizen welfare institutions are elderly people with poor mobility, fire accidents often cause serious casualties. The most common cause of death for immobile seniors at the scene of the fire is smoke [24]. Therefore, how to protect the safety of these elderly people is an urgent issue that needs to be thoroughly discussed. This study carried out an on-site evaluation on the fire safety of 53 institutions in Tainan, Taiwan, to understand the risk level of each institution. Tainan is located south of the Tropic of Cancer and has a subtropical climate. It covers an area of 2192 square kilometers and has a population of more than 1.88 million [25].

This study checked the risks in some small-scale institutions based on the Fire Protection Defense-in-depth Strategies. Similar to reactors in nuclear power plants, elderly with poor mobility are considered "subjects not to be harmed" to ensure that complied regulations and measures can effectively protect them [26]. Hopefully, these research results can provide a reference for future policy development.

2. Research Method

2.1. The Concept of Fire Protection Defense-in-Depth

Nuclear materials in the U.S. for non-military purposes are managed by the U.S. Nuclear Regulatory Commission (NRC). The concept of Fire Protection Defense-in-depth Strategies is to protect people from being harmed by leaking nuclear materials. The mechanism provides multiple layers of protection.

The basis for the protection mechanism is "Any complex, close-coupled system, no matter how well-engineered, cannot be said to be failure-proof". Failure of a protection layer may be attributable to the negligence of staff or a device/circuit fault. When one layer fails, the next protection layer becomes essential [27]. Figure 3 shows the three-layer protection mechanism.

Layer 1: Prevent fires from starting.

Layer 2: Rapidly detect, control, and promptly extinguish those fires that do occur.

Layer 3: Protect the nuclear reactor so that a fire that is not promptly extinguished by fire suppression activities will not prevent the safe shutdown of the plant. For Layer 3, this study focuses on preventing a fire from spreading.

This mechanism has effectively protected nuclear power plants from fires so far. Some studies also demonstrate that this strategy is considered [28,29] in elderly care institutions. Many elderly people in small-scale senior citizen welfare institutions are often unable to egress on their own during a fire, as evidenced by some past fire incidents. The similarity

between the two sites is that the aftermath of an accident is severe and irreparable. Since strategies involve activities such as strategic planning and thinking, appropriate strategies can integrate multiple fields, such as architecture, fire safety, and elderly care, without being restricted by regulations in a single field [30]. Therefore, this study applied this theory in fire protection in senior citizen welfare institutions and conducted risk reduction assessments.

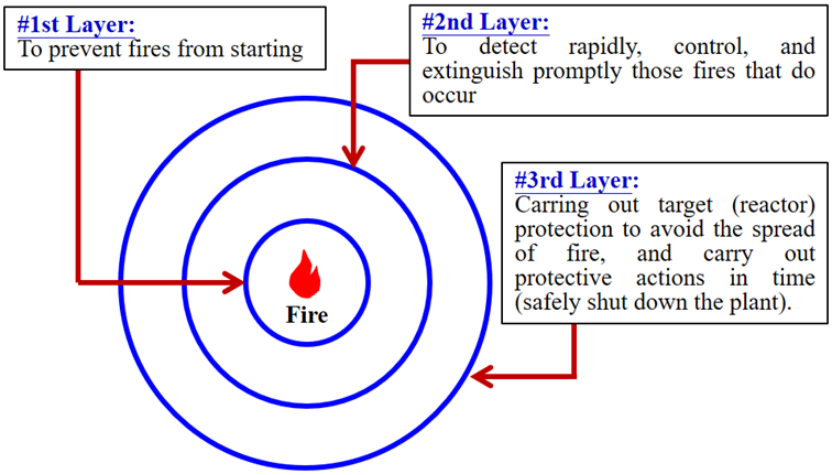


Figure 3. Fire protection defense-in-depth in U.S. nuclear power plants.

2.2. Fire Protection Defense-in-Depth Strategies

Mobility-impaired persons are considered "subjects that must not be harmed", and it is critical to develop appropriate protection strategies for them. A sound protection system should be incorporated with a passive building design, active firefighting system, and effective management [31–34]. Some places with high fire risks, such as bars or restaurants, often use curtains, which indeed facilitate the spreading of fire. Therefore, flame retardancy is specified [35]. This is the first layer that targets fire prevention.

According to the Standard for Installation of Fire Safety Equipment Based on Use and Occupancy, public places must be equipped with fire extinguishing equipment, such as fire extinguishers, automatic sprinkler equipment, or fire alarm devices [36]. This is the second layer to detect and control fires. According to the Taiwan Building Technical Regulations, fire compartments, fireproof doors, and fire-rated windows must be installed [37]. This is the third layer that aims at preventing a fire from spreading.

2.3. Site Visit and Counseling

In 2019 and 2020, the research team visited a total of 53 small-scale senior citizen welfare institutions, accounting for 46% of all such institutions in Tainan. Other welfare institutions are expected to be visited in the future depending on the funding.

All institutions visited were legally registered with the government. The research team first reviewed the characteristics of each institution in order to determine whether it could provide adequate fire safety protection. The main points of the site visit and counseling were as follows.

- Characteristic analysis of the institutions
- External environmental assessment
- Working conditions of the foreign staff
- Assessment of fire response
- Effectiveness of fire extinguishing equipment

3. Results and Discussion

3.1. Characteristics Analysis of the Institutions

Figure 4 shows the characteristics of the 53 institutions. Of them, 24 (45%) institutions were established before 2000. After the Jiji Earthquake in 1999, which was a strong

earthquake with a magnitude (ML) 7.3 that killed 2415 people and injured 11,305 people in central Taiwan, the requirement on seismic resistance of buildings was strengthened starting in 2000 [38]. According to the data, only half of the institutions met the old seismic resistance requirements.

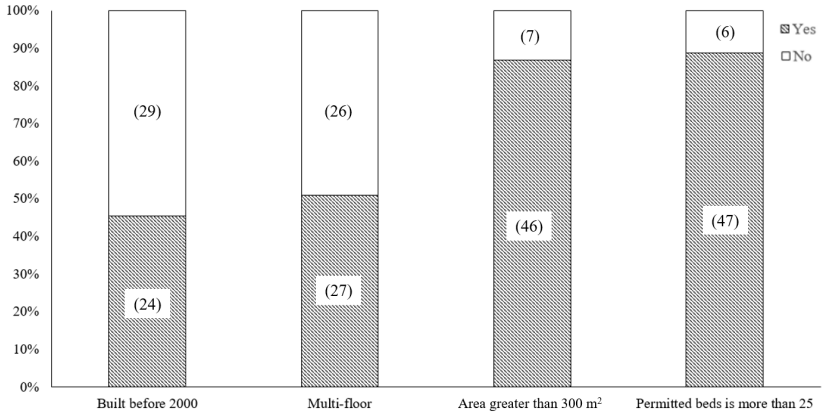


Figure 4. Service characteristics of interviewed institutions. ( ): Number of institutions.

Twenty-six (49%) institutions have multi-floor buildings. Table 3 lists the proportions of senior residents and staff under Taiwan laws. The proportions are defined based on regular service efficiency. However, if an emergency occurs, multi-floor buildings and single-floor buildings would have different evacuation conditions, especially different evacuation times if there are mobility-impaired persons. Based on the results of site visits, this study suggested that institutions with multi-floor buildings should arrange more night-shift staff than institutions with single-floor buildings in order to improve emergency evacuation efficiency.

Table 3. Number of cared senior citizens per nursing personnel and caregiver.

	Minimum Floor Area per Person (m^2)	Number of Cared Senior Citizen per Nursing Personnel (Person/Person)	Number of Cared Senior Citizen per Caregiver (Person/Person)	
			Daytime	Nighttime
Long term care institution	7	15	5	15
Small size nursing institution	5	20	8	25

Forty-six (87%) institutions have an area larger than 300 m^2. Under the fire codes before October 2018, not all senior citizen welfare institutions are required to have fire alarm systems installed. This requirement is only mandatory for institutions that have an area larger than 300 m^2. This indicates that some institutions have no systematic fire alarm systems. All ultra-small institutions have independent fire detectors installed that can detect fires; this is Layer 2 protection.

Forty-seven (89%) institutions have 25 or more senior residents. As listed in Table 3, these institutions arrange at least three night-shift staff, including one nurse practitioner and two caregivers. The division of work among the night-shift staff when an emergency occurs should be a key point for institutions' planning.

Figure 5 shows the total number of people of each mobility characteristic in the visited institutions. Among the 1833 seniors, 288 have no mobility difficulties, 1242 use wheelchairs, and 303 are bedridden. According to statistics, 84% of seniors in small-scale senior citizen welfare institutions are mobility-impaired and can only evacuate with the assistance of staff when an accident occurs. When an emergency occurs in institutions, adequate and well-trained staff play a vital role. The performance of night-shift staff would affect the ultimate scale of a disaster. Therefore, when developing the Fire Protection Defense-in-

depth Strategies, institutions should pay attention to the performance of night-shift staff in addition to fire protection equipment; this is Layer 3 protection.

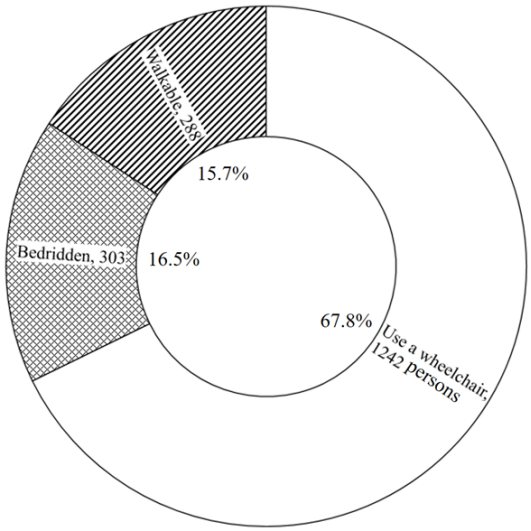


Figure 5. Analysis of residents' mobility.

3.2. External Environmental Assessment

There are some aspects of the external environment that some institutions need to pay attention to. First, the roads in front of some institutions are not wide enough, as shown in Figure 6. Narrow roads are not conducive to the passage of emergency vehicles. These institutions are advised to regularly discuss with fire services in their local jurisdiction on acquiring adequate support in case of an emergency; this is Layer 3 protection.

(**A**) (**B**)

Figure 6. (**A**,**B**) show some institutions are located in narrow alleys.

The second aspect concerns the characteristics of neighbors. Neighbors of some institutions engage in the recycling business or are small manufacturers with high fire risks and hazards. These institutions could easily become involved if their neighbors are on fire; this is Layer 1.

3.3. Working Conditions of Foreign Staff

Mobility-impaired elderly people in institutions require 24-h care, resulting in heavy workloads. Under Taiwan laws, institutions are able to employ foreign caregivers. Figure 7 shows the proportions of foreign caregivers. Only a small proportion of institutions do not

hire any foreign caregivers (5, 9%); most institutions have foreign caregivers (48, 91%), and all foreign caregivers are females. Ten (19%) institutions have a proportion of foreign caregivers below 1/4, while 12 (23%) institutions have over 1/2. Almost all foreign caregivers work night shifts.

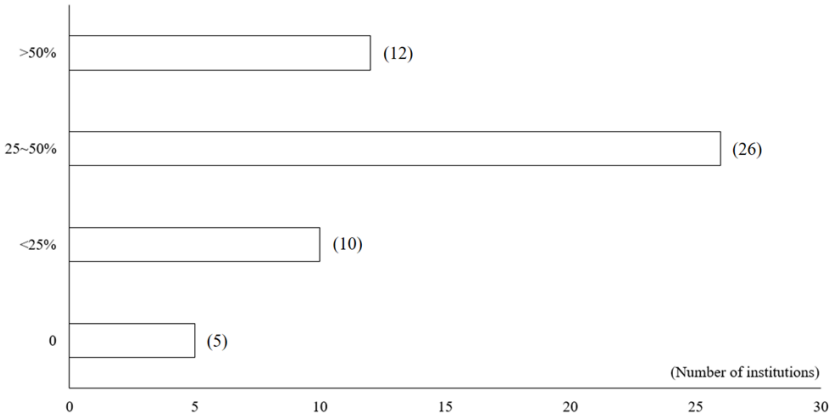


Figure 7. Percentage of foreign employees in each institution.

Foreign caregivers may have language barriers to understanding the instructions from their supervisors and the elderly residents. In addition to communication on the daily routines, fire safety training and emergency response also require good communication. Additionally, this study reviewed whether the institutions have foreign language versions of fire extinguishing equipment labels and operating instructions, as shown in Figure 8. Among the 48 (91%) institutions that employ foreign caregivers, 31 (58%) have foreign language versions. It is recommended that these institutions add signs and labels in foreign languages to facilitate emergency responses; this is Layer 2 protection.

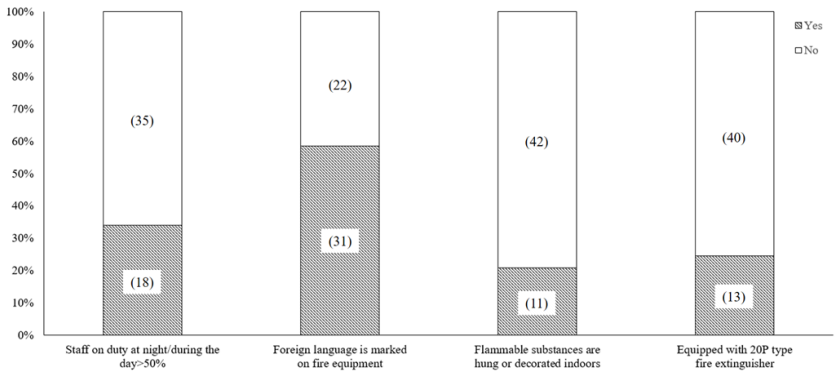


Figure 8. Analysis of fire emergency response ability. ( ): Number of institutions.

3.4. Assessment of Fire Response

The Euroclass system is recognized as the fire safety standard across Europe. It classifies fire response and evaluates multiple aspects, such as ignitability, flame spread, heat release, smoke production, and propensity for producing flaming droplets/particles. The system was introduced by the European Union in 2000 to ensure consistent quality levels across individual member states.

The number of staff available in institutions to assist with response and evacuation is important since most seniors have limited mobility. There is currently no regulation on the number of night-time emergency responders in Taiwan. If the number of night staff is reduced by half, the workload of each employee will be doubled, which is detrimental to the response to fire and the evacuation of residents.

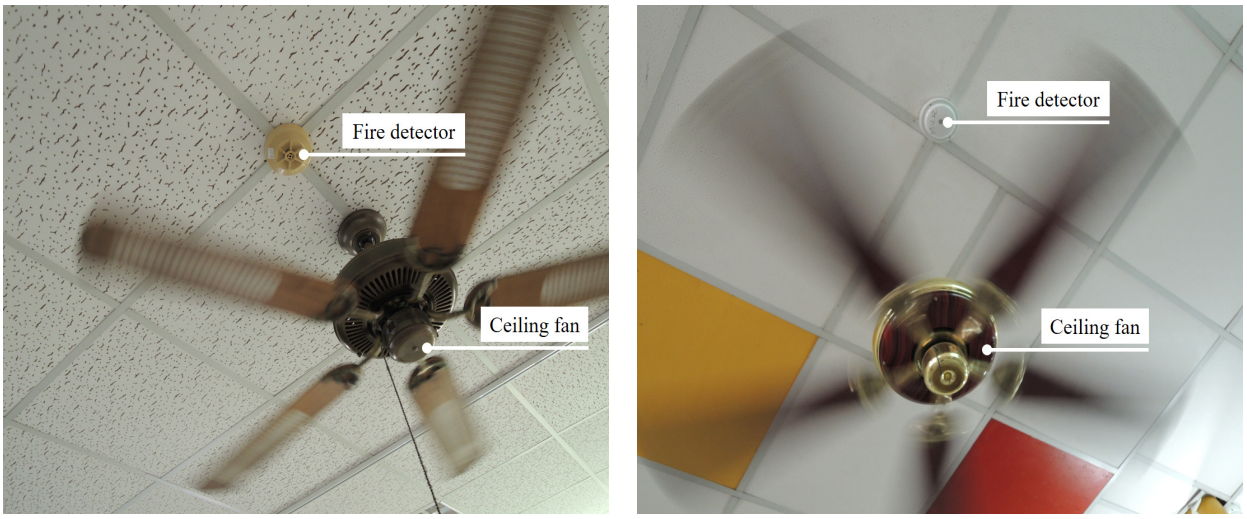
Figure 8 shows the statistics on night-shift staff. The night-shift manpower in 35 (66%) institutions is less than half of the day-shift manpower, indicating poorer night-shift staff

response capability. This is related to the effectiveness of Layer 2 protection. Eleven (21%) institutions use inflammable materials to create a "cozy" environment and atmosphere; this violates Layer 1 protection. Institutions are recommended to review whether their decorations use inflammable materials.

Small-scale institutions have only a few types of fire extinguishing equipment; hence, personnel response capability is of great importance. Among the 48 (91%) institutions that have female foreign caregivers, 13 (25%) installed 20P powder-type extinguishers. Being able to operate a fire extinguisher immediately and effectively is an important response item. A 20P powder-type extinguisher has a gross weight of 9.8 kg, including 6.5 kg of the extinguishing medium [39]. According to the survey results, almost all the night-shift staffs are female, so they might have more difficulty operating a 20P dry powder fire extinguisher than a 10P fire extinguisher. Institutions are recommended to replace 20P powder-type extinguishers with two light-weight 10P powder-type extinguishers to facilitate quick and appropriate operations; this is Layer 2 protection.

3.5. Effectiveness of Fire Extinguishing Equipment

In small-scale institutions, common fire extinguishing devices are fire alarms. Fire detectors are installed in rooms where seniors live. In the nighttime, effective fire detectors can detect fires early, allowing the staff to extinguish a fire as soon as possible; this is Layer 2 protection. Unfortunately, many institutions have fire detectors installed above the ceiling fans, as shown in Figure 9. In some rooms, the only fire detector is installed above the ceiling fan which may impair the detection function of the detector, undermining the Layer 2 protection [40].



(**A**) (**B**)

Figure 9. Fire detectors installed above ceiling fans are shown in (**A**,**B**). There are doubts about the performance of fire detectors and sprinklers disrupted by the airflow generated by ceiling fans.

The smoke released by a fire is the main contributor to casualties [41–44]. Early detection of fires and containment of smoke in a room are important in Layer 3 protection. According to Article 115 of the Standard for Installation of Fire Safety Equipment Based on Use and Occupancy, fire detectors must be installed 1.5 m away from fans [45]. In 37 (70%) institutions, the function of some fire detectors may be adversely affected by the air flow from ceiling fans or wall fans. Therefore, the effectiveness of these fire detectors must be re-evaluated.

Doors of seniors' rooms are designed for purposes of good ventilation and convenient indoor condition monitoring. Figure 10 shows that doors in 39 (74%) institutions cannot prevent the spreading of smoke, though they meet the standards in Taiwan. It is believed that preventing the spread of smoke should also be considered in the fire safety of senior

citizen welfare institutions to ensure the effectiveness of Layer 3 protection. This can be further discussed in subsequent studies.

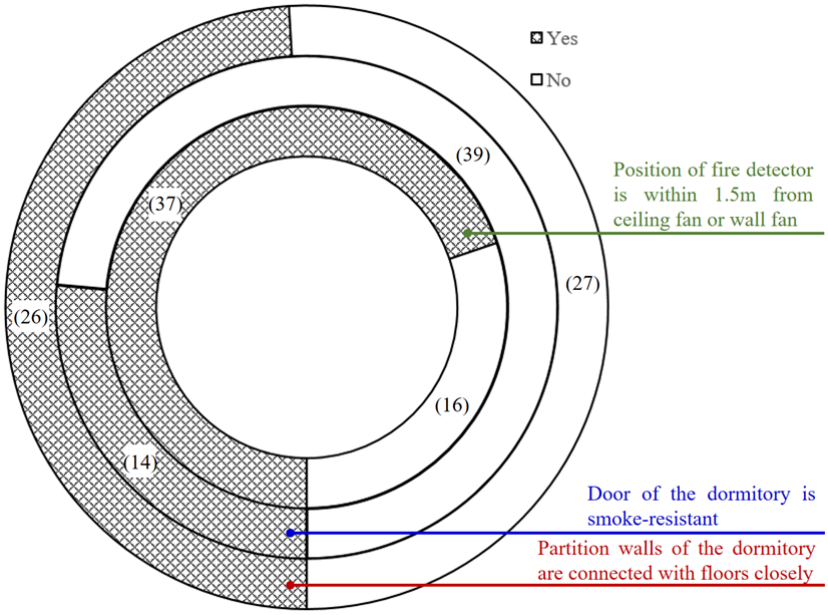


Figure 10. Analysis of fire safety hazards in the interviewed institutions. ( ): Number of institutions.

As shown in Figure 10, in 27 (51%) institutions, partition walls in rooms are not fully connected with the floor slabs and are only connected to the ceilings. In this case, the space above the ceilings of all rooms is connected. If a fire occurs, the fire and smoke will spread through the space above the ceilings; this violates Layer 3 protection.

4. Conclusions

Small-scale elderly care institutions have been established around Taiwan. In recent years, fire accidents occurred in some senior citizen welfare institutions, unfortunately causing heavy casualties. Enhancing the quality of care and safety of the elderly in such institutions is a pressing issue.

Similar to nuclear power plants, these institutions have clear and core targets for protection; these targets will suffer serious and irreversible consequences after a fire accident. Our research team visited 53 small-scale senior citizen welfare institutions currently operating in Taiwan, in order to identify potential hazards in fire safety and propose solutions based on Fire Protection Defense-in-depth Strategies. Based on the layer-by-layer effect of layered protection, some insightful findings are as follows:

Layer 1: Precautions

- Half of the institutional buildings meet new seismic codes.
- One-fifth of institutions hang flammable decorative items.
- A total of 84% of the elderly have poor mobility. Assistance is required to evacuate in the event of a fire incident.

Layer 2: Rapid Emergency Response

- All institutions are equipped with fire detectors.
- Half of the institutions are multi-story buildings. It is recommended that more night response personnel should be arranged.
- Two-thirds of institutions arrange less than half of the day-shift manpower for the night shift; strengthening nighttime resilience requires further exploration.
- Ninety percent of institutions employ foreign caregivers, all of whom are female. The suitability of fire-extinguishing equipment should be considered for night shift female caregivers.

- The effectiveness of institutions' fire detectors is affected by the airflow generated by nearby ceiling fans.

Layer 3: Limitations of fire spread

- It is very important to prevent the spread of fire and smoke in the room caught on fire. Preventing the spread of smoke from the door and the connection of the space above the ceiling has to be carefully checked.

Similar to reactors in nuclear power plants, the elderly with poor mobility are considered "subjects not to be harmed" to ensure that regulations and measures being complied with can effectively protect them. Due to the complex factors involved in the fire risk of small-scale institutions, establishing an appropriate disaster prevention strategy can integrate multiple fields, such as construction, fire protection, and elderly care, without being restricted by regulations in a single field.

Author Contributions: Conceptualization, methodology, validation, and investigation, S.-M.H. and S.-W.C.; validation, supervision, resources, and writing—original draft preparation, S.-C.W.; project administration, resources, and writing—review and editing, C.-H.S.; formal analysis and data curation, L.-P.C. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Ministry of Science and Technology under Grant no. MOST 109-2625-M-992-002.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: The funding from the Ministry of Science and Technology is acknowledged. We also thank Jhih-Ang Yang, Guo-Ruei Shih, and Dai-Han Li for their help in recording the scenes.

Conflicts of Interest: The authors declare no conflict of interest.

References

1. Yao-Rong, H. A field survey on the environmental characteristics of day care centres for the demented elderly in Taiwan. In *Ageing in Place*; Edward Elgar Publishing: Cheltenham, UK, 2020; pp. 48–59.
2. Yeh, M.-J. Long-term care system in Taiwan: The 2017 major reform and its challenges. *Ageing Soc.* **2019**, *40*, 1334–1351. [CrossRef]
3. World Health Organization. *Report of the World Health Organization. Active Ageing: A Policy Framework*; WHO: Geneva, Switzerland, 2002; pp. 1–37.
4. Statistics Department of the Ministry of the Interior. Available online: https://www.moi.gov.tw/stat/index.aspx (accessed on 12 January 2022).
5. National Development Council. Inquiry System for Population Estimation. Available online: https://pop-proj.ndc.gov.tw/international.aspx?uid=69&pid=60 (accessed on 12 January 2022).
6. Hussein, S.; Ismail, M. Ageing and Elderly Care in the Arab Region: Policy Challenges and Opportunities. *Ageing Int.* **2017**, *42*, 274–289. [CrossRef]
7. Kuo, C.-M.; Chen, L.-H.; Liu, C.-H. Is it all about religious faith? Exploring the value of contemporary pilgrimage among senior travelers. *Asia Pac. J. Tour. Res.* **2019**, *24*, 379–392. [CrossRef]
8. Yang, J.Y.; Kim, S.S.; Lee, J.Y. A Study on the Causes of Elderly Crime and Its Countermeasures in the Transition of Elderly Society. *Korean Secur. Sci. Rev.* **2019**, *61*, 307–332. [CrossRef]
9. Kim, J.; Kim, S. The Impact of Population Characteristics and Government Budgets on the Sustainability of Public Buildings in Korea's Regional Cities. *Sustainability* **2020**, *12*, 5705. [CrossRef]
10. Radcliff, T.A.; Horney, J.A.; Dobalian, A.; Macareno, B.O.; Kabir, U.Y.; Price, C.; Strickland, C.J. Long-Term Care Planning, Preparedness, and Response Among Rural Long-Term Care Providers. *Disaster Med. Public Health Prep.* **2020**, 1–4. [CrossRef]
11. Ministry of Health and Welfare. Long-Term Care 2.0 Implementation Status and Review Project Report. Available online: https://www.mohw.gov.tw/dl-64981-86dfd40d-7294-40d6-b914-52ac5483b43d.html (accessed on 20 January 2022).
12. Rashid, A.; Azizah, M.; Rohana, S. The Attitudes to Ageing and the Influence of Social Support on It. *Br. J. Med. Med. Res.* **2014**, *4*, 5462–5473. [CrossRef]
13. Qian, Y.; Qin, W.; Zhou, C.; Ge, D.; Zhang, L.; Sun, L. Utilisation willingness for institutional care by the elderly: A comparative study of empty nesters and non-empty nesters in Shandong, China. *BMJ Open* **2018**, *8*, e022324. [CrossRef]
14. Annisa, M.; Wati, D.N.K. The relationship between sleep hygiene and sleep quality among residents of an elderly care institution in DKI Jakarta. *UI Proc. Health Med.* **2020**, *4*, 89–97. [CrossRef]

15. Folk, L.; Gales, J.; Gwynne, S.; Kinsey, M. Design for Elderly Egress in Fire Situations. In Proceedings of the 14th International Fire Science and Engineering Conference (Interflam), Windsor, UK, 4–6 July 2016; pp. 775–781.
16. Tseng, W.-W.; Shen, T.-S.; Liao, S.-F.; Tseng, C.-C. To Improve the Care Environments by Using Fire Safety Engineering for Existing Small-Scale Hospitals in Taiwan. In *Fire Science and Technology*; Springer: Singapore, 2017; pp. 373–381.
17. Zhang, G.; Huang, D.; Zhu, G.; Yuan, G. Probabilistic model for safe evacuation under the effect of uncertain factors in fire. *Saf. Sci.* **2017**, *93*, 222–229. [CrossRef]
18. Moussavi, S.; Chatterji, S.; Verdes, E.; Tandon, A.; Patel, V.; Ustun, B. Depression, chronic diseases, and decrements in health: Results from the World Health Surveys. *Lancet* **2007**, *370*, 851–858. [CrossRef]
19. Cwirlej-Sozanska, A.; Wilmowska-Pietruszynska, A.; Sozanski, B.; Wisniowska-Szurlej, A. Analysis of Chronic Illnesses and Disability in a Community-Based Sample of Elderly People in South-Eastern Poland. *Med. Sci. Monit.* **2018**, *24*, 1387–1396. [CrossRef]
20. Shih, Y.-T. *Research on the ASET and RSET of Nursing Homes Fire—The Case Study on a Nursing Home*; Central Police University: Taoyuan City, Taiwan, 2017.
21. National Fire Agency. *Standard for Installation of Fire Safety Equipments Based on Use and Occupancy*; Article 22-1. 2021; National Fire Agency: Taipei City, Taiwan, 2021.
22. Ministry of the Interior. *Fire Services Act*; Article 6. 2021; Ministry of the Interior: Taipei City, Taiwan, 2021.
23. Construction Agency. *Building Technical Regulations*; Article 99-1. 2021; Construction Agency: Taipei City, Taiwan, 2021.
24. Wang, T.-Y.; Tsai, K.-C. Investigation Report of Bei-Men Hospital Fire in Taiwan on October 23, 2012. In *Proceedings of the 11th Asia-Oceania Symposium on Fire Science and Technology, Taipei, Taiwan, 24–25 October 2018*; Springer: Singapore, 2020; pp. 857–865.
25. Tainan City Government. Available online: https://www.tainan.gov.tw/cp.aspx?n=13292 (accessed on 9 February 2022).
26. Lim, J.; Kim, H.; Park, Y. Review of the regulatory periodic inspection system from the viewpoint of defense-in-depth in nuclear safety. *Nucl. Eng. Technol.* **2018**, *50*, 997–1005. [CrossRef]
27. Hidekazu, Y.; Morten, L.; Ming, Y.; Muhammad, H.; Zhijian, Z. Configuration of risk monitor system by plant defense-in-depth risk monitor and reliability monitor. *Int. Electron. J. Nucl. Saf. Simul.* **2012**, *3*, 140–152.
28. Saleh, J.H.; Haga, R.A.; Favarò, F.M.; Bakolas, E. Texas City refinery accident: Case study in breakdown of defense-in-depth and violation of the safety–diagnosability principle in design. *Eng. Fail. Anal.* **2014**, *36*, 121–133. [CrossRef]
29. Papakonstantinou, N.; Tommila, T.; O'Halloran, B.; Alanen, J.; Van Bossuyt, D.L. A Model Driven Approach for Early Assessment of Defense in Depth Capabilities of Complex Sociotechnical Systems. In Proceedings of the ASME 2017 International Design Engineering Technical Conferences and Computers and Information in Engineering Conference, Cleveland, OH, USA, 6–9 August 2017.
30. Mintzberg, H.; Ghoshal, S.; Lampel, J.; Quinn, J.B. *The Strategy Process: Concepts, Contexts, Cases*; Pearson Education: London, UK, 2003.
31. Shetty, N.K.; Soares, C.G.; Thoft-Christensen, P.; Jensen, F.M. Fire safety assessment and optimal design of passive fire protection for offshore structures. *Reliab. Eng. Syst. Saf.* **1998**, *61*, 139–149. [CrossRef]
32. Chow, W.K. Building Fire Safety in the Far East. *Archit. Sci. Rev.* **2011**, *48*, 285–294. [CrossRef]
33. Troitzsch, J.H. Fires, statistics, ignition sources, and passive fire protection measures. *J. Fire Sci.* **2016**, *34*, 171–198. [CrossRef]
34. Choi, M.; Lee, S.; Hwang, S.; Park, M.; Lee, H.-S. Comparison of Emergency Response Abilities and Evacuation Performance Involving Vulnerable Occupants in Building Fire Situations. *Sustainability* **2019**, *12*, 87. [CrossRef]
35. Ministry of the Interior. *Fire Services Act*; Article 11. 2021; Ministry of the Interior: Taipei City, Taiwan, 2021.
36. National Fire Agency. *Standard for Installation of Fire Safety Equipments Based on Use and Occupancy*; Article 14. 2021; National Fire Agency: Taipei City, Taiwan, 2021.
37. Construction Agency. *Building Technical Regulations*; Article 76. 2019; Construction Agency: Taipei City, Taiwan, 2019.
38. Construction Agency. *Taiwan Building Seismic Design Code*; Construction Agency: Taipei City, Taiwan, 2000.
39. Kauffman Co. Common Fire Extinguisher Sizes and Weights. Available online: https://www.kauffmanco.net/blog/common-fire-extinguisher-sizes-weights/ (accessed on 12 January 2022).
40. Hung, S.; Chong, K.; Liu, S.; Su, C.; Chen, L. Effect analysis of the airflow field generated by ceiling fans on fire detectors using model experiments and Schlieren photography. *Case Stud. Therm. Eng.* **2021**, *26*, 101087. [CrossRef]
41. Chow, C.; Chow, W.K.; Lu, Z. Assessment of smoke toxicity of building materials. In Proceedings of the 6th Asia-Oceania Symposium on Fire Science & Technology, Daegu, Korea, 17–20 March 2004; pp. 132–142.
42. Półka, M. Wpływ dodatków ograniczających palność na właściwości dymotwórcze elastycznych i półsztywnych pianek poliuretanowych. *PrzemysŁ Chem.* **2017**, *1*, 54–58. [CrossRef]
43. Półka, M. Impact of flame retardants on smoke generating properties of acrylic pressure-sensitive adhesive transfer tapes Wpływ środków ogniochronnych na właściwości dymotwórcze poliakrylanowych samoprzylepnych taśm transferowych. *PrzemysŁ Chem.* **2017**, *1*, 160–164. [CrossRef]
44. Kukfisz, B.; Półka, M. Analysis of Oxygen Index to Support Candle-like Combustion of Polyurethane. *Procedia Eng.* **2017**, *172*, 604–611. [CrossRef]
45. National Fire Agency. *Standard for Installation of Fire Safety Equipments Based on Use and Occupancy*; Article 115. 2021; National Fire Agency: Taipei City, Taiwan, 2021.