A Study on the Fire Safety Awareness of Elderly Facility Staff:

-The Analyzation of Staff's Anxiety Against Night Fire Based on the Mathematical Quantification Theory Class III –

高齢者社会福祉施設職員の火災安全意識に対する研究

－数量化三類を用いた夜間火災への不安に関する分析－

○MA Zhiyao[*1]，OKADA Naoko[*2]，OHNISHI Kazuyoshi[*3]，MURAI Hiroki[*4]

馬　致遥，岡田尚子，大西一嘉，村井裕樹

　　本研究では、第一に延焼抑止や避難の容易性に関わる施錠システム、防火防煙のための区画性能、排煙システムの違いや避難器具と、ユーザーである職員の不安感の関係について数量化分析を行って、近年普及しつつある介護単位であるユニット型と従来型による不安感に繋がる要因構造を明らかにした。

　　第二に、勤務経験、夜勤職員一人当たりのベッド数、訓練に関わる諸要因など、人的条件と不安感の関係について、数量化分析を行い、経験の浅い職員に対しては、ベテランとの防火知識の共有や訓練マニュアルの充実が有効であることを有用な知見として示した。

1. Introduction

1-1 Background

With the increasing of the elderly, Japan ushered into super-aged society. Japan built a rich variety of elderly facility with high density. And, because of the high rate of the casualty in elderly facility fire, the fire of the elderly facility has become a social issue nowadays. For this issue, consider the fire safety system and education system's construction is necessary.

1-2 Literature review

For this research, the literature review as the follow shows:

(1) Kazuyoshi OHNISHI's research [1]

From the research, the author determined that the elderly facilities have insufficient fire safety measures for the night fire. Therefore, to cooperate with residents or organization in the area is necessary. In this paper, the research did not find the weak point through the anxiety of the elderly facilities for the fire safety measures for the night fire.

(2) Taichi YAMAMURA's research [2]

According to the experiment of evacuation, the researcher determined the situation of evacuation time in the fire through the human behavior. In this paper, the research did not clarify the factors that impact the evacuation time in the fire through the staff of elderly facilities' anxiety.

(3) Hiroki MURAI's research [3]

According to the experiment of evacuation, the researcher determined the elderly facilities' current situation that the fire safety training would become a burden to the staff and residents. However, the fire safety training is necessary for the facilities. The research did not clarify the current situation of staff's fire safety training.

*1　神戸大学大学院　博士後期課程・修士（工学）
*2　神戸大学都市安全研究センター　博士（工学）
*3　神戸大学大学院　准教授・博士（工学）
*4　日本福祉大学健康科学部　准教授・博士（工学）

*1 Graduate School of Engineering, Kobe Univ., M. Eng
*2 Research Center for Urban Safety and Security, Kobe Univ., Dr. Eng
*3 Assoc. Prof., Graduate School of Engineering, Kobe Univ., Dr. Eng
*4 Assoc. Prof., Nihon Fukushi Univ., Dr. Eng.

(4) Atsunori HAYASHIDA's research [4)]

From the research, the author determined that the smoke spreading is quite critical in elderly facilities' fire. In addition, elderly's reaction for smoke may become slow. Therefore, the smoke prevention measure became very important. In this paper, the research did not clarify the factors that impact the smoke spreading in the fire through the staff of elderly facilities' anxiety.

1-3 The method and the purpose of the research

This research distributed questionnaire to 348 elderly facilities in Kumamoto, Hokkaido (Sapporo and Otaru), Nagoya and Kobe. According to process and analyze the result of the questionnaire, the research determined the current situation of the facility's fire safety system and education system's construction. And the result could provide the basis for the further research for any other new education method in the future.

2. The questionnaire research

2-1 The outline of the questionnaire research

2-1-1 The outline of the research execution

This research distributed the questionnaire in total 348 elderly facilities in Kumamoto, Hokkaido (Sapporo and Otaru), Nagoya and Kobe. And the date of the questionnaire distribution as the follow shows.

Kumamoto: Jun 2013

Hokkaido (Sapporo and Otaru): August 2013

Nagoya: November 2014

Additional research: October 2015

Kobe: November 2016

The situation of the questionnaire's distribution and recycle as the follows shows. (Table 1)

Table1. The situation of questionnaire's distribution and recycle

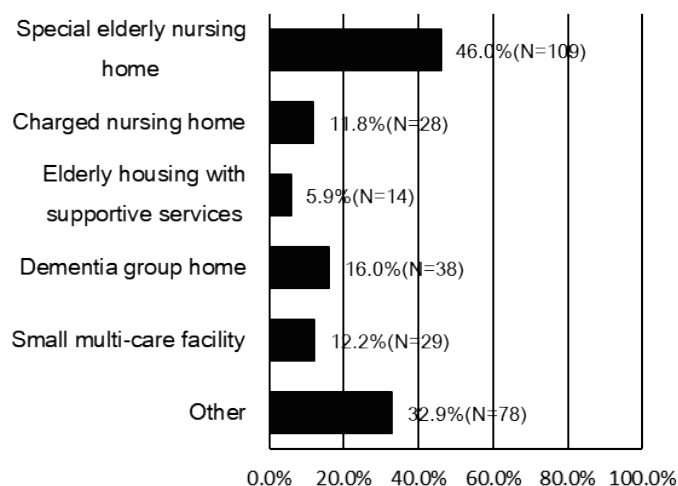|	Distribution	Recycle	The ratio of recycle
Kumamoto	128	101	78.9%
Hokkaido	55	31	56.4%
Nagoya	43	33	76.7%
Additional research	33	21	63.6%
Kobe	89	51	57.3%
Total	348	237	68.1%

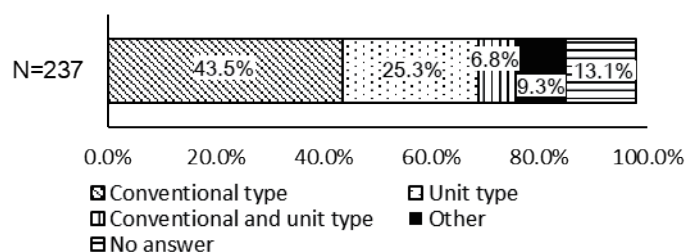Figure1. The usage of the elderly facility

Figure2. The architecture's type of the elderly facility
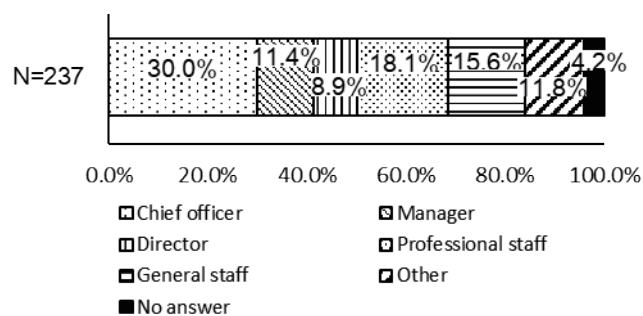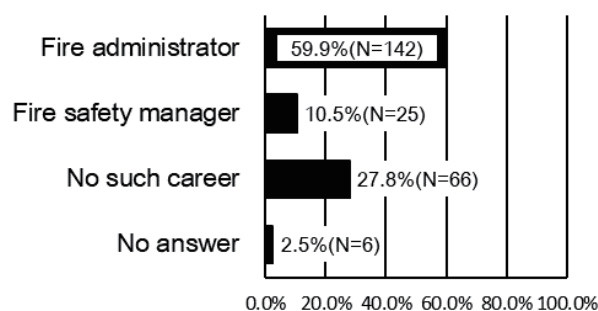

Figure3. The position of the respondents

Figure4. The career calendar of the respondents (N=237)

2-2 The analyzation of the questionnaire

2-2-1 The current situation of the elderly facility

The related information about the usage of the elderly facility (Figure1), in 237 respondents, special elderly nursing home is the most, accounting for 46.0 percent. 46 respondents made multiple selections. Besides, 78 respondents selected the option "other". The contents of option "other" included in-home long-term care support office, light cost nursing home, elderly nursing home and nursing home for blind elderly.

For the architectural type (Figure 2), the architectural type was separated into conventional type and unit type, the conventional type includes side corridor type, central corridor type and corridor type. The unit type is a new architecture type of the elderly facility. In 237 respondents, most of the facilities are conventional type, accounting for 43.5 percent. The second is unit type, accounting for 25.3 percent. The third is the facility have both types, accounting for 6.8 percent.

For the identity of the respondents (Figure4), most of the respondents are in charge of fire administration in the elderly facility, totally accounting for 84.0 percent. (Figure3) In addition, more than half respondents have experience of being the fire administrator, totally accounting for 70.4 percent. Therefore, their opinion could represent the current situation of the elderly facility.

2-2-2 The respondents' anxiety for the evacuation system

In the anxiety for the evacuation system (Figure5), the option "No balcony or no route to balcony" is the most, accounting for 21.5 percent. And the whole options were organized into three groups, "Anxiety for the redundancy of evacuation route", "Anxiety for insufficient smoke spreading measure" and "Anxiety for the facility with insufficient evacuation space". Then the groups were used in the analyzation of the mathematical quantification theory class III (short for MQTC III). The item of the MQTC III as the follows shows. (Table2)

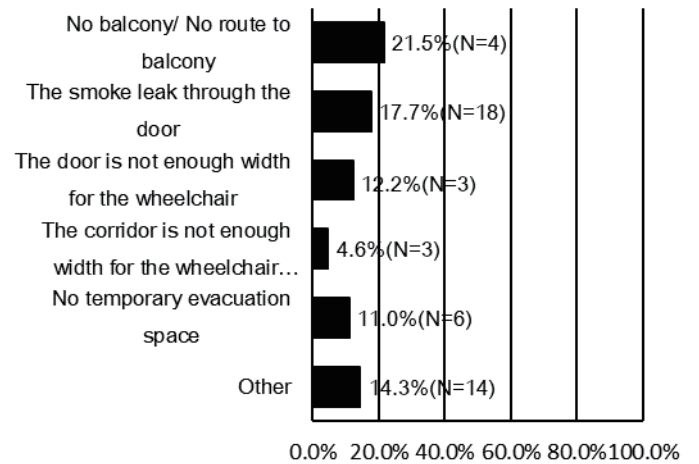For analyse the reason of the respondents' anxiety

Figure5. The anxiety for the evacuation system (N=237)

Table2. The item of the MQTC III (Evacuation System)

Anxiety for the facility	●	Insufficient evacuation space
	■	The redundancy of evacuation route
	◆	Insufficient smoke spreading measure
Architectural type	▲	Conventional type
	▲	Unit type
Equipment	□	Natural smoke eject system
	◇	Electronic unlocking system
	○	Evacuation equipment
The stair's and elevator's door have no linkage with the smoke detector	△	Yes
	△	No

Table3. The contribution ratio of the MQTC III (Evacuation System)

Solution	Eigenvalue	Contribution Ratio	Cumulative Contribution Ratio
1	0.219832	0.219832	0.219832
2	0.166192	0.166192	0.386024
3	0.13162	0.13162	0.517644
4	0.122648	0.122648	0.640292
5	0.106185	0.106185	0.746476
6	0.098861	0.098861	0.845337
7	0.083745	0.083745	0.929082
8	0.070918	0.070918	1
Total	1		

Table4. The result of calculation with MQTC III (Evacuation System)

|	Item	Category	Axis1	Axis2
Anxiety for facility	Insufficient evacuation space	Yes	-1.194877282	0.13561402
		No	1.556119251	-0.176613607
	The redundancy of evacuation route	Yes	0.099120059	-3.585329648
		No	-0.02202668	0.796739922
	Insufficient smoke spreading measure	Yes	1.078151846	1.950742945
		No	-0.539075923	-0.975371473
Architectural type		Conventional	0.174829039	-1.255083125
		Unit	-0.178396979	1.280697067
Equipment	Natural smoke exhaust system	Have	0.957204363	0.390550735
		None	-1.536564899	-0.626936707
	Electronic unlocking system	Have	1.399606384	0.14069133
		None	-1.822743198	-0.183225918
	Evacuation equipment	Have	1.299379994	-1.295775606
		None	-0.997738209	0.994970555
Stair's and elevator's door have linkage with smoke detector		Have	0.451138774	-0.220262527
		None	-0.460345687	0.224757681
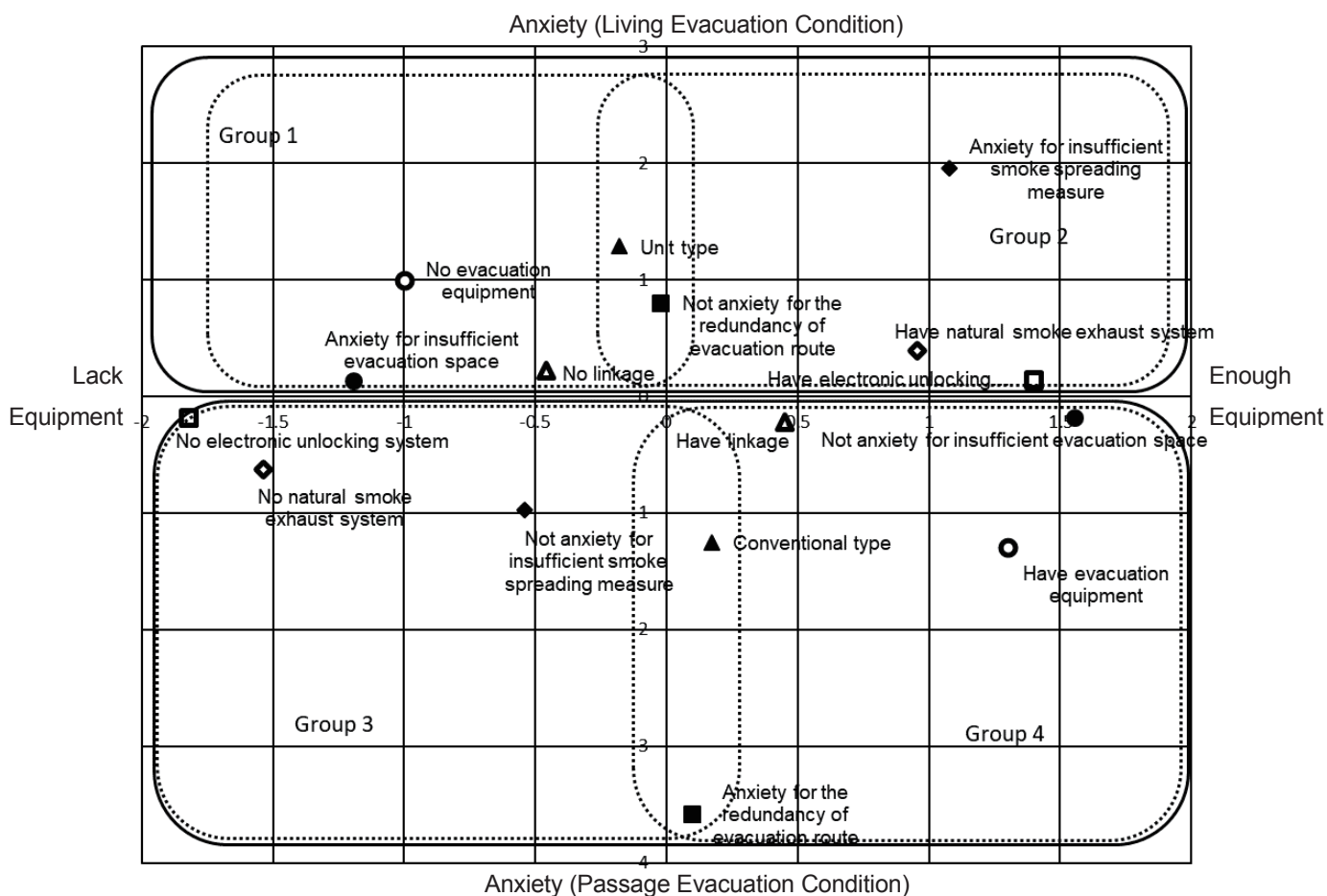
Figure6. The scatter plot of the analyzation's result (Evacuation System)

for the facility. The research used MQTC III as the method to execute the analyzation. According to the calculation with MQTC III. The contribution ratio and cumulative contribution ratio as the table shows. (Table3) Although the cumulative contribution ratio is not high, the result of analyzation still could reflect the current situation of elderly facilities' fire safety measure and its trend. The result of calculation was put into a scatter plot. (Table4)

The result of the analyzation shows (Figure6), in Axis1, plus part is defined as "complete evacuation system", the minus part is defined as "insufficient evacuation system". In Axis2, plus part is defined as "the reason of respondents' anxiety for evacuation through the living room", minus part is defined as "the reason of respondents' anxiety for evacuation through the passage". Based on the type of architecture, the items in the scatter plot are classified into two large groups and based on the distance between items in scatter plot, two large groups are separated into four small groups any further. For the large group, In the upper group (Group 1 and Group 2), unit type as a new architecture type of the elderly facility, people no need have anxiety for the redundancy of the evacuation route because of such type of architecture have no passage. In the lower group (Group 3 and Group 4), the conventional type includes side corridor type, central corridor type and corridor type. These three types have a common point, they have long passage. In evacuation operation, it would play a great role in evacuation. The elderly, especially the elderly with low mobility, they need evacuation with wheelchair or stretcher, the passing condition of the passage would become an issue. Therefore, with the situation that the fire safety management is not clear, the respondents may have anxiety for the redundancy of evacuation route.

For the small group, in Group 1, the unit type could evacuate the residents through the living room, a spacious, public space. The respondents no need to have anxiety about the evacuation route's condition. However, lacking evacuation equipment would cause

the evacuee could not reach an evacuation space timely, it would compress the evacuation space that could be used in a fire. Lacking electronic unlocking system and door- smoke detector linkage system, it would cause the door cannot locking or unlocking correctly in the fire. It could place the evacuee in a dangerous situation or the evacuee could not reach an evacuation space timely. In a sense, it would compress the evacuation space that could be used in a fire as well. Therefore, the respondents have anxiety for the insufficient evacuation space in the fire.

In Group 2, based on the same reason, the respondents have no anxiety for the redundancy of the evacuation route. However, the unit type lacks extra openings to assistance the smoke exhaust, it mainly relies on active smoke exhaust equipment, such as using natural smoke exhaust system to exhaust the smoke by or according to fire doors to prevent the smoke spreading. All the measures rely on staff's manual control. In a sense, it needs staff's well training and awareness of fire safety. Although the electronic unlocking system is controlled automatically, it still has the risk of system failure, in that case, it will extend the time that exposure to the smoke and cause heavy casualties. The respondents may consider above factors and have no confidence for their facilities' software and hardware construction, they have anxiety for the smoke spreading measures.

In Group 3, the characteristic of conventional type is the long passage, it would be a key point in evacuation operation because all the personnel's evacuation operation was executed through the passage. Therefore, the respondents have anxiety for the redundancy of the evacuation route. And the situation that the facilities lack electronic unlocking system could obstruct the evacuation operation, it may aggravate the respondents' anxiety for the redundancy of the evacuation route. However, because of the passage have multiple openings, their function is equivalent to a passive smoke exhaust system. Especially side corridor type, it could assist the smoke exhaust system to exhaust the smoke, and the corridor type could exhaust the smoke according

to chimney effect as well, although the facilities lack natural smoke exhaust system, the respondents have no anxiety for smoke spreading measures.

In the Group 4, based on the same reason, the respondents have anxiety for the redundancy of the evacuation route. The door‐smoke detector linkage system could lock the door in fire automatically according to the smoke detector, to prevent the fire and smoke spreading. It expands the range of the evacuation space that could be used in the fire. The evacuation equipment's using accelerated the speed of evacuees that reach the evacuation space, the evacuees have much more evacuation spaces to choose when the fire occurred. In a sense, this equipment expands the range of evacuation space. Therefore, the respondents have no anxiety for the insufficient evacuation space.

2-2-3 The anxiety for the management for the residents

In the anxiety for the fire safety system (Figure7), the option "Have anxiety for insufficient staff at night" is the most, accounting for 61.2 percent. For the analyzation of the MQTC III, the options were picked or organized into three groups, "Insufficient staff at night", "Insufficient knowledge" and "Insufficient related training". The item of the MQTC III as the follows shows. (Table5)

For analyze the reason of the respondents' anxiety for the management for the residents. The research used the same method to execute the analyzation. According to the calculation with MQTC III. The contribution ratio and cumulative contribution ratio as the table shows. (Table6) Although the cumulative contribution ratio is not high, the result of analyzation still could reflect the current situation of elderly facilities' fire safety measure and its trend. The result of calculation was put into a scatter plot. (Table7)

For analyze the scatter plot (Figure8), based on the different current situation of the elderly facilities' staff and fire safety management, the research adds two additional axes, Additional Axis A and Additional Axis B. For the meaning of the Axis1 and Axis2, the plus of Axis1 is defined as "Sufficient fire safety
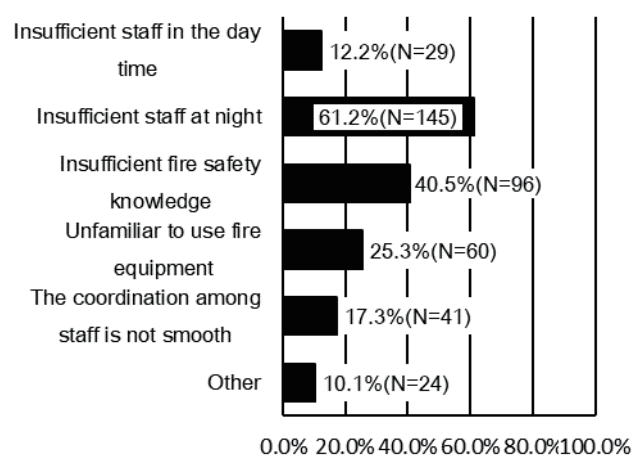

Figure7. the anxiety for the management for the residents (N=237)

Table5. The item of the MQTC III (The management for the residents)

Anxiety for the staff	●	Insufficient staff at night
	■	Insufficient knowledge
	▲	Insufficient related training
Working career	□	Over 13 years
	□	Below 13 years (include 13)
Beds per staff (Night)	○	Below 20 beds (include 20) per staff (Night)
	○	Over 20 beds per staff (Night)
Have own training manual	△	Have own training manual
	△	No own training manual
Share training experience	◇	Share training experience
	◇	No share training experience

Table6. The contribution ratio of the MQTC III (The management for the residents)

Solution	Eigenvalue	Contribution Ratio	Cumulative Contribution Ratio
1	0.229359	0.229359	0.229359
2	0.176661	0.176661	0.40602
3	0.144805	0.144805	0.550825
4	0.138875	0.138875	0.6897
5	0.1334	0.1334	0.8231
6	0.089078	0.089078	0.912178
7	0.087822	0.087822	1
Total	1		

Table7. The result of calculation with MQTC III (The management for the residents)

|	Item	Category	Axis1	Axis2
Anxiety for the facility	Insufficient staff at night	Yes	-1.210505842	-0.156245352
		No	1.144478251	0.147722878
	Insufficient knowledge	Yes	0.357587919	-0.768467536
		No	-0.64930438	1.395375262
	Insufficient related training	Yes	1.249580463	0.219497058
		No	-1.181421529	-0.207524491
Working career		Below 13 years (include 13)	1.035325005	1.194024936
		Over 13 years	-1.372930985	-1.583380894
Bed per staff　（Night）		Below 20 beds/staff (include 20)	0.417090141	0.813231503
		Over 20 beds/staff	-0.895517068	-1.746055874
Have own training manual		Have	0.94698355	-0.946981964
		None	-1.355908264	1.355905994
Share training experience		Yes	0.774834222	-0.958011404
		No	-1.067549372	1.319926823
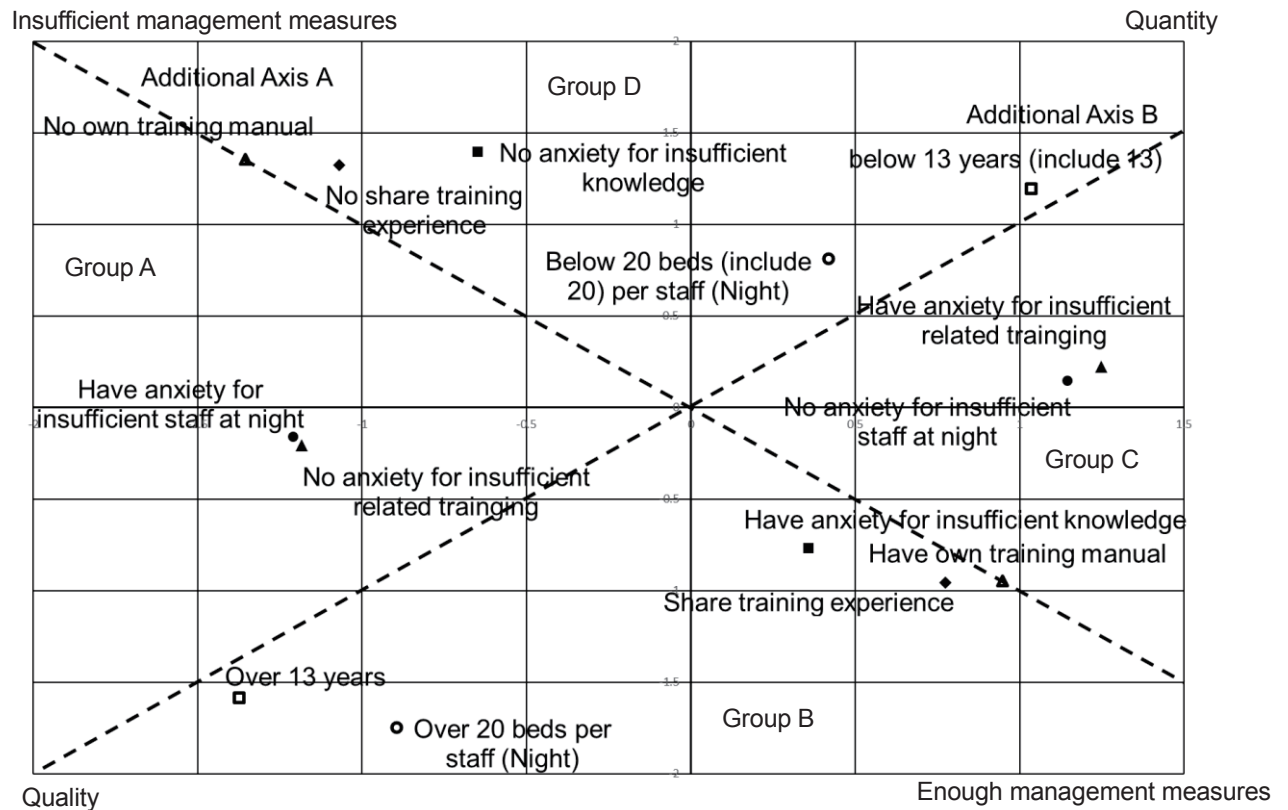
Figure8. The scatter plot of the analyzation's result (The management for the residents)

awareness and measure with the strategy of quantity", the minus part of Axis1 is defined as "Insufficient fire safety awareness and measure with the strategy of quality". The plus part of Axis2 is defined as "Insufficient fire safety awareness and measure with the strategy of quantity", The minus part of Axis2 is defined as "Sufficient fire safety awareness and measure with the strategy of quality". For the meaning of the Additional Axis. In Additional Axis A, the plus part is defined as the "insufficient management measures", the minus part is defined as "enough management measures". In Additional Axis B, the plus part is defined as "quantity", the minus part is defined as "quality". The Additional Axis A separated the items into two groups according to the current situation of the respondents' facilities' staffs. In the group that upper the Additional Axis A (Group C and Group D), the item below 13 years means the staffs' working career below 13 years, in another word, they have not gained enough experience in number of the bed per staff is below 20, in another word, the facility has enough staff working at night. Therefore, the respondents in this group have no anxiety for the insufficient staff at night. On the contrary, the group that below the Additional Axis A (Group A and Group B), it has item over 13 years and over 20 beds per staff, it means the facility has less staff than the group that upper the Additional Axis A. Therefore, the respondents have anxiety for the insufficient staff at night. However, their working career is much longer than another group, in another word, they have gained much more experience than another group. It shows that for address the issue about fire safety at night, each facility executes different strategy, one is the facilities rely on quality to cover the issue that the insufficient staff, another one is the facilities rely on quantity to cover the issue that the insufficient experience was caused by short working career.

Another additional axis, Additional Axis B, separated the scatter plot into two parts as well, it mainly about the information of management for the residents from the aspect of method and awareness.

The part that on the left of Additional Axis B (Group A and Group D), from the aspect of the method, the respondents neither have the behaviour that shares the training experience nor have training manual to make education for the recruit. From the aspect of respondents' anxiety, the respondents neither have anxiety with insufficient knowledge nor have anxiety for insufficient related training. It means the group that on the Additional Axis B's left neither have enough method to improve the fire　safety level nor have willing to improve the current situation of fire safety, in another word, they have insufficient fire safety awareness. In another group, the group that on the Additional Axis B's right (Group B and Group C), from the aspect of the method, these facilities share the training experience and according to making training manual to training the recruit. From the aspect of respondents' anxiety, these facilities have anxiety for insufficient knowledge and related training. It means the group that on the Additional Axis B's right have methods to strengthen the fire safety level so far, they still pay attention to the method of fire safety improvement and they thought that they still have space to improve it.

For the overlapping part, in left overlapping part of the scatter plot (Group A), it shows the facilities rely on the quality with the insufficient method for the fire safety. The facilities did not organize their training experience as a training manual to spread the training experience to the recruit because of they adopt the strategy for fire safety that relies on quality and the respondents have no anxiety for the insufficiently related training. The respondents just have anxiety for insufficient staff at night because of the insufficient staff at night. In lower overlapping part of the scatter plot (Group B), it shows the facilities rely on the quality with sufficient method for the fire safety.　They organized their training experience as a training manual to spread the training experience to the recruit and sharing their training experience with each other. In addition, the respondents have anxiety for insufficient knowledge. The staff of facilities' behaviour may come from such

subjective thought. For the development in the future, the research advised that the facilities that in the left overlapping part need take the facilities in the lower overlapping part as an example, organized the training experience as a training manual and got ready for spread training experience to the recruit. In the upper part of the scatter plot (Group D), it shows the facilities rely on the quantity with the insufficient method for the fire safety. The facilities did not share the training experience or organized their training experience as a training manual to spread the training experience to the recruit may because of the facilities adopt the strategy for fire safety that relies on quantity, the staff's working career is too short to have abundant experience or knowledge to share. In addition, the respondents have no anxiety for insufficient knowledge, it shows the respondents have not realized their knowledge lacking. In right overlapping part of the scatter plot (Group C), it shows the facility relies on the quantity with sufficient method for the fire safety. They organized their training experience as a training manual to spread the training experience to the recruit and sharing their training experience with each other. Because of the facilities adopt the strategy for fire safety that relies on quantity, the staff's working career is too short to receive sufficient training. It reflected on respondents' anxiety correctly, the respondents have anxiety for insufficient related training and no need to have anxiety for insufficient staff at night. For improve the facilities' fire safety level, the research advised that these facilities that in the upper overlapping part need take the facilities in the left overlapping part as an example, according to sharing the knowledge and experience from fire safety training to improve the staff's fire safety knowledge and experience level.

3. Conclusion

3-1 The conclusion of the questionnaire research

From the analyze the scatter plot of the evacuation system and the management for the residents, the research comprehended the current situation of the elderly facility.

3-1-1 The anxiety for the evacuation system

From the scatter plot of the evacuation system analyzation. For the architecture type, because of the characteristic of the conventional type, it may have potential risks in evacuation route from the aspect of management or design. However, from the aspect of smoke spread measure, even though the conventional type has insufficient smoke exhaust system, the corridor's opening could assist to exhaust the smoke. Therefore, the respondents did not have anxiety for the smoke spreading measures.

On the contrary, because of the unit type have no passage like conventional one, the respondents have no reason to have anxiety for the redundancy of evacuation route. However, in the condition that the facilities have insufficient evacuation equipment, the respondents still have anxiety for the evacuation space issue. In addition, because of the characteristic of the unit type, if the fire occurred, it relies on the active smoke spreading measure such as natural smoke exhaust system or electronic unlocking system to create the opportunity of evacuation. Whatever the equipment skilled operation or the automatic system's reliable, it depends on the facilities' strong hardware and software's construction. Because of the respondents have no confidence for that, they have anxiety for smoke spreading measures.

3-1-2 The anxiety for the management for the residents

According to the analyze the scatter plot of the management for the residents, it shows that the elderly facilities address the fire safety issue at night in different ways, one is relying on the quality of the staff, another one is relying on the quantity of the staff.

The scatter plot shows, the researched facilities separated into two parts from the aspect of method and awareness. One is neither have enough method nor have willing to improve it. Another group has enough method to strengthen the fire safety level and it still searches for more improvement space.

For this current situation, the first group needs set the second group as an example and improve its own awareness of fire safety. In addition, improve the alert

to the fire risk.

For the specific parts' analyzation, there are four overlapping parts on the scatter plot. They present four current situations of the elderly facilities' strategy and fire safety system's construction. Group A shows the facilities because of their strategy that adopted quality relying, they have not prepared for experience teaching to the recruit. On the contrary, the Group B have methods to teach fire safety experience and knowledge to the recruit according to making training manual and sharing the experience with each other. Therefore, for the development in the future, the Group A should set Group B as an example and teach the recruit fire safety experience and knowledge according to making training manual and sharing experience with each other. Group D shows the facilities because of their strategy that adopted quantity relying, the staff's career is too short to gain enough experience to share with each other or making training manual. In addition, they have not realized their fire safety experience or knowledge's lacking. On the contrary, the Group C's facilities adopted the same strategy, but they have such awareness and taken action to gain their own experience and knowledge according to making training manual and sharing experience with each other. Therefore, for improving the level of fire safety awareness, Group D should set Group C as an example, gain their own experience and knowledge according to making training manual and sharing experience with each other.

3-2 The future subject

In the future subject, for improve the accuracy of the questionnaire's result, the research would improve the content of the questionnaire, the method of the analyzation and expand the scope of the research's object.

The research also asked the information of the Fire Image Game to the respondents, as a new type of the education method, the examination for the effective of Fire Image Game is valuable. In the future subject, the research would increase the content of the Fire Image Game's effective examination particularly.

Reference

1) OHNISHI Kazuyoshi, A Study on Fire Prevention in Welfare Facility for the Elderly : Through the Questionnaire Research in Facilities in Tokyo, 日本建築学会近畿支部研究報告集, 計画系 (51), pp.117-120, 2011.05.25

2) YAMAMURA Taichi, SATOH Hiroomi, KURIOKA Hitoshi, KOBAYASHI Kyoyichi and SEKIZAWA Ai, Study on Human Behavior in Fire Evacuation Drill at Care Facility for the Elderly, 日本建築学会学術講演梗概集 2013(防火), pp.315-318, 2013.08.30

3) MURAI Hiroki, AMANO Keiko and HOKUGO Akihiko. (2011, July). Basic research on the realities of fire drills: Research on safe shelter at a fire of special elderly musing homes, 学術講演梗概集. A-2, 防火,海洋,情報システム技術 2011, pp. 213-214, 2011-07-20

4) HAYASHIDA Atsunori, and OHNISHI Kazuyoshi, Research study on the actual conditions of fire safety at the house and social welfare institution as living space for elderly people part1, 日本建築学会近畿支部研究報告集. 計画系(54), pp. 177-180, 2014.05.26