Passengers' likely behaviour based on demographic difference during an emergency evacuation in a Ro-Ro passenger ship

Abstract

By examining the characteristics of passengers on a ship route between the Shandong and Liaodong Peninsula, through a questionnaire survey, this paper aims to address the likely behaviours of passengers during emergency evacuation and the demographic differences among these behaviours.

A questionnaire survey of 1,380 passengers shows that passengers on board are more alert and are more likely to proactively respond to evacuation alarms (62.5%), observe others' actions (59.1%), follow evacuation instructions (67.9%), obey the crew (66.2%), queue patiently (63%), return to the cabin when their families are left behind (65.1%), and be cooperative (59%) rather than competitive (44%). The multinomial logistic regression results show that passengers who are older, with limited mobility, that have more experience aboard ships and are part of a larger group, will be more likely to proactively confirm the authenticity of evacuation events. Men, elderly individuals, people who are part of a larger group and with less experience in evacuation education are more likely to follow others. When the family is left behind, elderly individuals and people who are part of a larger group are much more likely to choose to return to their cabins. Similarly, elderly passengers with larger groups are much more likely to choose to help others.

Although questionnaire research has some limitations, such as a hypothetical response and closed questions, the research results are of great significance for helping passenger ship managers to develop appropriate management rules, and conduct effective evacuation education activities.

Keywords: Human behaviour, Passenger ship safety, Emergency evacuation, Demographic characteristics, Crowd management

1 Introduction

1.1 Background

The global passenger ship market has become large-scale, and the passenger capacity has been gradually increasing in recent years (Li and Cai, 2019; Vanem and Skjong, 2006). According to the data from the Lloyds Register Fairplay and Lloyds Maritime Information Unit database, the number of global Ro-Ro passenger ships is 2,020 in 2011, accounting for 2/3 of the global number of passenger ships, similarly, the transportation capacity is 1,372,871 passengers, accounting for 65% of the global one (Corrignan et al., 2011). The accident probability of a large passenger ship is deemed to be very low, however, in the event of an accident, the consequences are considered catastrophic. This is demonstrated in tragedies such as, the Estonia passenger ship that sank in 1994, where 852 SOBs (Souls on Board) lost their lives; the Dashun Ro-Ro passenger ship that sank after the fire in 1999, where only 22 of the 312 SOBs were rescued, with a direct economic loss of about ¥90m; and the Sewol Ro-Ro passenger ship that sank in 2014, with 304 SOBs either declared dead or missing (Sun et al., 2018a; Kim et al., 2016; Nevalainen, 2015). Thus, the evacuation of large passenger ships gradually became a primary concern of the safety field (Ahola and Mugge, 2017; Ahola et al., 2014; Vanem and Skjong, 2006).

To actively improve the safety level of passenger ships, especially after the Estonia accident, the International Maritime Organization (IMO) began to amend the SOLAS Convention to improve the safety of passenger ships (IMO, 2019; Nevalainen, 2015). In 2016, after many revisions and additions, the Maritime Safety Committee (MSC) approved the "Revised guidelines on evacuation analyses of the new and existing passenger ships" at its 96th session as part of SOLAS Convention II-2/13.3.2.71. This revision made evacuation analysis mandatory not only for Ro-Ro passenger ships but also for other passenger ships constructed on or after January 1st, 2020 (Li and Cai, 2019; IMO, 2016).

However, the data and parameters specified in the guideline are based on civil building evacuations, and do not take into account the effects on human behaviour of ship movement or family group behaviour, and rarely provide an effective management strategy (Chen et al., 2018, 2015; IMO, 2016; Lee et al., 2003). Compared with the land-based evacuation, evacuating people from crowded passenger ships is a complex and difficult task. If the passenger's behaviour characteristics are not fully understood in advance, it is difficult to manage a crowd in an emergency (Ahola et al., 2014; Glen et al., 2001).

Today, compared with the land-based evacuations (building, train and airplane), the research on ship evacuation is relatively limited due to the complex structure ships, the highly variable the marine environment and the difficulty in obtaining evacuation data. There is limited empirical data on ship evacuation, especially the data related to the walking speed and human behaviour (Zhang et al., 2016; Vanem and Skjong, 2006). Therefore, there is still a need to systematically analyse the likely behaviour of passengers during the evacuation of passenger ships to supplement and advance existing research in this important area.

1.2 Objective and scope of the study

The Ro-Ro passenger ship is one of the successful types of vessel operating in the world. It has the characteristics of flexible operation and fast speed, making it extremely popular on many ship routes, particularly on short-sea routes (IMO, 2019).

The Ro-Ro passenger ship market in the Bohai Bay area started in 1986 and achieved unprecedented success in the early 1990s in China. Then in 1999, the Ro-Ro passenger ship "Dashun", travelling from the Shandong Peninsula to the Liaodong Peninsula, sank after a fire. This resulted in the Ro-Ro passenger ship market suffering a short “frozen period”. At the beginning of 2016, according to data from the China Ocean Shipping (Group) Company (COSCO)’s Shipping Passenger Transport Co., Ltd., the number of passenger ships travelling between the Shandong Peninsula and the Liaodong Peninsula reached 46 each day, with

79 approximately 20 million people and 600,000 cars carried annually (Yu, 2016).

80 This paper aims to investigate the demographic characteristics and the likely behaviours
81 of ship passengers during emergency evacuation by conducting a questionnaire survey on a
82 Ro-Ro passenger ship between the Shandong Peninsula and the Liaodong Peninsula.

83 Although the method of questionnaire survey has been widely used in the analysis of
84 human behaviour choices, the authors have found that there is no systematic study of the
85 relationship between the demographic characteristics of a Ro-Ro passenger ship and the likely
86 behaviour under emergency scenarios. Therefore, this research will bridge this gap, which can
87 be used to support and expand existing passenger ship evacuation models and simulation
88 software through providing reliable empirical data. Simultaneously, studying the demographic
89 differences in passengers' likely behaviours during evacuation can provide valuable insights
90 for future evacuation planning, and help to improve the understanding of passengers' likely
91 behaviours. It is also helpful for crowd management during the emergency evacuation of Ro-
92 Ro passenger ships, and improves the safety of Ro-Ro passenger ships.

93 **2 Literature review**

94 The guideline performance standard stipulates that the total evacuation time of a Ro-Ro
95 passenger ship is no longer than 60 minutes (IMO, 2016). Currently, there are many models
96 and software packages for evacuation simulation (Kim et al., 2019; Hifi, 2017; Galea et al.,
97 2013; 2012; 2010; Meyer-König et al., 2007; Kim et al., 2004), but the simulation results are
98 often quite different from the actual evacuation time. For example, the "Norman Atlantic" Ro-
99 Ro passenger ship evacuated the entire ship by rescue helicopter and lifeboat due to a fire in
100 the car deck and the total evacuation process lasted 35 hours (Pospolicki, 2017). Therefore,
101 there is still a strong need for reliable empirical data, especially experimental data in
102 emergency situations to develop and verify the evacuation model and improve the accuracy
103 and authenticity of the result.

To provide empirical data for model validation, the research group at the University of Greenwich conducted three sea trials on a Ro-Ro passenger ship and cruise ships (Galea et al., 2013; 2012; 2010), and collected three types of data: passenger response times, evacuation time and questionnaire data, in which the data in the questionnaire section was not presented in the articles (Nevalainen, 2015). Simultaneously, researchers have conducted human walking experiments under listing conditions (Kim et al., 2019; Sun et al., 2018a; 2018b; Zhang et al., 2016; Meyer-König et al., 2007). They simulated the condition of the ship in a listing state and obtain the average human walking speed. However, considering the safety and ethical issues, the experiments above were mostly carried out under controlled conditions, as it was difficult to replicate an emergency scene (Shiwakoti et al., 2017; 2016).

Regarding the lack of research in ship evacuation, some researchers have advocated the use of research results of building evacuations, adapting the research results from the field of civil evacuations to ship evacuation. To highlight the similarities between building evacuations and ship evacuations, a questionnaire survey of 100 passengers was carried out randomly in Ancona, a mother port of Italy's cruise ships, to understand the passengers' familiarity with the emergency situations and likely behaviour (Casareale et al., 2017). By analysing the existing land-based research literature in detail, it is possible to see that the likely behaviour of passengers in emergency situations can be divided into a number of categories, which are outlined in the following sections.

2.1 Pre-evacuation

Pre-evacuation is sometimes described as pre-movement (Bode and Codling, 2019), meaning that during the response/reaction phase, people may engage in activities such as packing items, finding others, investigating the cues, and seeking confirmation from others before evacuating (Haghani et al., 2019a; Galea et al., 2017). Pre-evacuation time is an important part of the total evacuation time and is affected by various factors, such as social

influence (Bode and Codling, 2019; Lovreglio et al., 2016), distance from the exit (Haghani et al. 2016) and safe location (Haghani et al. 2019a). Although most evacuation simulation software tools can be used to predict pre-evacuation behaviour in normal or emergency situations, the performance of this behaviour is often oversimplified (Lovreglio et al., 2016). As very few accidents are the same, and humans do not react uniformly to them, it is still necessary to learn more about the delays in evacuation behaviour due to personnel awareness and perception (Shiwakoti et al., 2019a; 2016). The existing literature on land-based traffic accidents shows that different people choose to respond to emergencies actively or passively. Some people do not evacuate immediately after hearing the alarm until the staff confirm with the Public Address (PA) system. However, some studies show that people can move to emergency exits or muster stations in a timely manner when they sense danger (Shiwakoti et al., 2017; Fridolf et al., 2013). Simultaneously, some studies have shown that pre-evacuations are affected by environmental factors, and people initiate evacuation actions at different times after the evacuation alert (Bode and Codling, 2019; Haghani et al. 2019a; Lovreglio et al., 2019). Questionnaire surveys on cruise ships were conducted to explore passengers' likely behaviours when hearing the evacuation alarm. The results showed that after hearing the alarm, 88% of passengers choose to confirm the accuracy of the incident (Casareale et al., 2017).

2.2 Path-finding

Currently, regarding the path-finding during emergency evacuation, some researchers have used mathematical models to analyse the path-finding behaviour of passengers (Kim et al., 2019; Ni et al., 2017; Kim et al., 2004). A number of researchers investigated the path-finding behaviour of ship passengers. Research conducted by Casareale et al. (2017) shows that 42% of people rely on their own understanding of the muster station, and 88% of them said they would follow the guidance of others. It is surprising that the passenger's trust in the crew is 100%, regardless of the crew's level or role, and 76% of passengers said they would

follow their advice in path-finding activities. Similarly, studies also show that in a panic situation, driven by the desire to escape from danger, people's decision-making processes are not necessarily logical. Even if there is a closer evacuation exit, people are also more likely to use a familiar evacuation exit (Lovreglio et al., 2016; Nevalainen, 2015).

2.3 Behaviour when there is exit congestion

Passengers show varying levels of impatience when the exits are congested, and data studies show that people are much more impatient than normal in an emergency (Haghani et al., 2019b; 2016). Mass disasters show that when there is exit congestion, people are more likely to make less risky choices, ignore favourable exits, and choose to wait in line, leaving the alternate exit idle (Shiwakoti et al., 2017; Hurley, 2016; Zur and Breznitz, 1981). Research conducted by Shiwakoti et al. (2017) shows that 43% of people stated that they will choose the less crowded exit. Furthermore, some studies also show that passengers tend to follow the guidance of the crew, and individuals act randomly without the crew's guidance. In contrast, people form a queue when there is a crew member to provide guidance (Casareale et al., 2017).

2.4 Count flow behaviour

In the evacuation of high-rise buildings, there are bidirectional flows with people evacuating downstairs and firefighters going upstairs. The impact of a bidirectional flow of people is significant for both descending and ascending personnel (Cłapa et al., 2015). In the evacuation process of ship passengers, as well as crew members returning to the cabin to rescue passengers, there will also be passengers returning to the cabin to find valuables, relatives and friends; this is particularly true for parents who will return to find their children (Glen et al., 2001; Kvamme, 2017). In existing evacuation models, some researchers have used mathematical modelling methods to simulate the counter flow-avoiding behaviour of personnel and employed advanced evacuation simulation tools to produce experimental results for use by the IMO (Kim et al., 2019; Ha et al., 2012).

2.5 Competition and cooperation behaviour

Existing evacuation studies have showed that in emergencies, people show competitive or cooperative behaviours such as shoving, trampling, or staying calm and helping each other (Shiwakoti et al., 2017; Sime, 1995). In the "Costa Concordia" accident, some male passengers tried to push away the crowd and forcibly entered lifeboats, causing some passengers to fall from the steps and become injured (Kvamme, 2017; Elnabawybahriz and Hassan, 2016). Compared with competitive behaviours, many fire accident cases show that in an emergency, the first response of the evacuation personnel is to help each other. Some people will return to the fire zone to find relatives, whereas staff will return to the fire area to help customers and show heroic behaviour (Hurley, 2016; Aguirre et al., 2011). To better understand the impact of competitive behaviour and cooperative behaviour in an evacuation, some mathematical simulation tools have been used to simulate the push behaviour and help behaviour of people through mathematical models (von Sivers et al., 2016; Song et al., 2006).

2.6 Group behaviour

Another salient phenomenon in the process of emergency evacuation is the behaviour of evacuees in social groups, i.e., social groups with close relationships, such as relatives and friends. In this instance, people support each other in the process of evacuation and negotiate to determine the evacuation strategy (Kvamme, 2017; Mawson, 2007; Sime, 1983). For example, during the "Costa Concordia" a woman and her colleagues packed their luggage and went to the embarkation station together (Casareale et al., 2017). To fully evaluate the evacuation efficiency of ships and manage personnel in high-density areas, it is necessary to consider the family and group behaviour of the personnel (Shiwakoti et al., 2017; Kim et al., 2004; Lee et al., 2003).

2.7 Impatient behaviour

In the case of short evacuation time available, the evacuated people usually show irrational,

impulsive or inappropriate behaviour. This behaviour coupled the increase of crowd density, will cause the evacuated people to become impatient; the walking speed will increase; competition and push behaviour will increase (Haghani et al., 2019b; Shiwakoti et al., 2019b; Vanem and Skjong, 2006). In the "Costa Concordia" accident, passengers began to become restless due to the sound of wind and waves hitting the ship, and during the boarding process some passengers chose to jump into the water thus the evacuation scene was out of control (Kvamme, 2017). If factors such as passenger psychological panic caused by the complex environment of the ship are not taken into account, the evacuation analysis will be divorced from reality and not instructive (Lee et al., 2003). Therefore, it is necessary to understand whether passengers will display impatient behaviour in the case of emergency evacuation, and whether it has a certain relationship with the educational background, social experience or psychological quality (Nevalainen, 2015).

2.8 Carrying luggage

For the evacuation analysis under the influence of obstacles of passenger ships, some researchers have studied the interaction between personnel and obstacles by combining the cellular automaton model or social force model, but the obstacles studied are mostly walls, tables, *etc*. (Ni et al., 2017; Ha et al., 2012; Vanem and Skjong, 2006). In the “Costa Concordia” accident, despite the heavy listing of the ship, there were still many elderly people who were reluctant to leave their luggage items until the rescuers force them to give up their personal belongings (Kvamme, 2017). Therefore, it is necessary to study the probability of personnel carrying luggage during evacuation, with respect to the impact of the movement of people and the entire evacuation time.

2.9 Temporary leadership behaviour

In the case of emergency evacuation, when there are no staff in the vicinity, some passengers will participate in the process of guiding the crowd evacuation due to the internal

responsibility of the individual (Hurley, 2016). Current research indicates that, a majority (92%) of those who do not understand emergency evacuation procedures, tend to rely on temporary leadership (Casareale et al., 2017; Hou et al. 2014). When leaders are unable to maintain leadership, teams will choose new leaders (Kuligowski, 2011). In the “Costa Concordia” accident, evacuation personnel clearly showed competitive behaviour and chaotic reactions, while passengers' spontaneous leadership behaviour and some calm behaviour quickly eased the chaos (Kvamme, 2017).

There are some similarities between a passenger ship evacuation and a land-based evacuation. Considering the particularity of the dynamic environment on board a ship and the complicated behaviour of personnel under the influence of the particular environment, passengers’ own travelling experiences and their familiarity with the ship, passengers’ choices of behaviour during ship evacuation may be more complicated than typical choices during land-based evacuations (Nevalainen, 2015; Glen et al., 2001). Although some researchers have studied the emergency evacuation behaviour of passengers on passenger ships, the sample data of the survey is relatively small, and due to the different data of ethnicity, cultural background, and education level, the likely behaviour of personnel may also be different.

3 Data and method

3.1 Description of the study scope

The passenger ship transport across the Bohai Bay is one of the major routes in China. It is the longest cross-strait passenger route and a high-risk sea area for maritime transport (Yantai, 2017). By the end of 2017, there were 23 Ro-Ro passenger ships serving Bohai Bay, which had a daily passenger capacity of 32,340 people and 3,442 parking spaces. In 2017, the Bohai Bay Ro-Ro passenger ship completed transportation of 5.5 million passengers, and 1.24 million vehicles, with an annual increase of 6% and 9% over 2016, respectively.

COSCO Shipping Passenger Transport Co., Ltd. is a state-owned sea passenger transport

enterprise directly under the management of COSCO Shipping Group. This company mainly undertakes maritime transportation of passengers and vehicles in China's coastal areas, especially in the Bohai Bay. It has eight large luxury Ro-Ro passenger ships such as "Bang Chui Dao" and "Yong Xing Dao". As an example of size, "Yong Xing Dao" has a length of 167.5 m, a width of 25.2 m and a tonnage of 24,572, as well as 23 crew members and 27 service staff, a passenger capacity of 1,400 and a car capacity of 2,000. The ships travel to and from the Shandong Peninsula and Liaodong Peninsula once a day.

A questionnaire survey was designed to investigate the demographic characteristics of passengers on the route and their likely behaviours during emergency evacuation. The survey's relevant ethics clearance was obtained from Dalian Maritime University's Human Research Ethics Committee and approved by the ship's Master and the company. Then the survey was carried out in a random, voluntary, autonomous and innominate form after the passengers were on board. The survey was disseminated on 3rd April by service staff on board the ship and returned to researchers on 18th May 2019. Prior to the survey, the research group trained the service staff so that passengers could be given detailed answers when they had questions about a problem (e.g. an evacuation experience). Each questionnaire took approximately 5 minutes to complete.

3.2 Measure method

Based on the existing research results, after communicating with the passenger ship staff, the research group designed a preliminary questionnaire. 6 volunteers were arranged to distribute an initial survey on the Ro-Ro passenger ship on the route in February 2019 and 241 completed survey questionnaires were received. Based on the results of the initial survey and the feedback from the respondents, the research group adjusted the questionnaire. After the adjustment, the research group conducted a questionnaire survey on the route again to analyse the reliability and validity of the questionnaire.

279 Reliability is an indicator of the consistency or stability of the measurement results. The
280 most commonly used approach is Cronbach's alpha reliability coefficient method with an alpha
281 value over 0.5 considered acceptable. An ideal method for validity analysis is to use factor
282 analysis to measure the structural validity of the scale. The Kaiser-Meyer-Olkin (KMO)
283 statistic test and Bartlett test of Sphericity (BTS) are generally used for suitability analysis. The
284 closer the KMO value is to 1, the more suitable it is for factor analysis. When the KMO value
285 is greater than 0.5, it is considered suitable for factor analysis. BTS is used to test whether the
286 correlation matrix is a unit matrix; thus, if $P < \alpha$, the null hypothesis can be rejected, which
287 also indicates that there is correlation between variables and is suitable for factor analysis (Sun
288 et al., 2019; Shiwakoti et al., 2016). Those requirements of reliability and validity were applied
289 to design the questionnaire. After the questionnaire met the requirements for reliability, validity
290 and the objectives of the survey, the final survey (refer to appendix A) was conducted from
291 April 2019 which lasted 45 days.
292 The questionnaire is divided into two parts: basic information and emergency evacuation
293 behaviour. The basic information section investigates the passenger's demographic
294 characteristics, such as gender, age group, education level, mobility, experience aboard ship,
295 the number of people travelling together, and experience of ship evacuation education/training.
296 The emergency evacuation behaviour is divided into pre-evacuation behaviour, path-finding
297 behaviour, behaviour during exit congestion, counter flow behaviour, competition and
298 cooperation behaviour, group behaviour, impatient behaviour, temporary leadership behaviour
299 and carrying luggage. The participants' responses were measured using a 5-point Likert scale,
300 ranging from 1 to 5, where "1" represents Very Unlikely, and "5" represents Very Likely.
301 The pre-evacuation behaviour is divided into waiting for the staff to confirm, escaping
302 immediately, observing the movements of others, and proactive confirmation. The path-finding
303 behaviour is designed to understand the choice of passenger escape route, such as choosing the

304 nearest exit, choosing the most familiar exit, following the majority, and following the
305 evacuation guide or PA. When the exit is congested, the behaviour of passengers choosing the
306 escape route is investigated. It is divided into queuing patiently, self-finding other exits,
307 squeezing forward, and obeying the crew. The counter flow behaviour is divided into returning
308 when valuables are left behind and returning when families are left behind. Competition and
309 cooperation behaviours are divided into pushing others and helping others during the process
310 of evacuation. Each of the groups, group behaviour, impatient behaviour, leadership behaviour,
311 and carrying luggage include only one question. That is, when evacuating and escaping, they
312 will find a companion to escape together. When there is a fire, they will feel impatient, and will
313 follow the team's temporary leader and carry luggage.

314 ***3.3 Participants in the survey***

315 In this survey, a total of 1,800 questionnaires were disseminated, 1,550 of them were
316 retrieved, and 1,380 valid questionnaires were obtained after the incomplete and damaged
317 questionnaires were weeded out. Thus the proportion of valid questionnaires was 89%. The
318 demographic characteristics of the 1,380 respondents are shown in Table 1.

319
320
321 **Table 1**
Demographic characteristics of survey participants

Demographic characteristics	Classification	Frequency	Percentage
Age	16 and below	83	6%
	17-25	376	27.2%
	26-30	234	17%
	31-40	138	10%
	41-50	263	19.1%
	51-60	247	17.9%
	61 and above	39	2.8%
Gender	Male	569	41.2%
	Female	811	58.8%
Education level	Primary and below	248	18%
	Secondary school	653	47.3%
	College	311	22.5%
	Graduate students and above	168	12.2%
Mobility level	Very poor	61	4.4%
	Poor	131	9.5%
	Neutral	452	32.8%
	Good	387	28%
	Very good	349	25.3%
Experience on board	0	119	8.6%
	1	273	19.8%
	2-4	776	56.2%
	5 or more	212	15.4%
Number of people travelling together	Alone	122	8.8%
	1	209	15.1%
	2-5	553	40.1%
	6-10	401	29.1%

	11 or more	95	6.9%
Evacuation education/ training experience	Never	385	27.9%
	Have, but do not remember	536	38.8%
	Once a year	213	15.4%
	More than once a year	246	17.8%

3.4 Data analysis

Statistical analyses were conducted with SPSS (Version 22.0). To test the possibility of a specific behaviour, depending on whether the sample data satisfies a normal distribution, the one-sample T-test or the Wilcoxon one-sample test in the non-parametric test section is employed to verify that the average of the individual variables is different from the neutral score of 3. If the sample data satisfies the normal distribution, the one-sample T test is selected, otherwise, the Wilcoxon one-sample test is selected. If the null hypothesis that the mean is equal to the neutral value of 3 is rejected, on average, then a score greater than 3 is likely to occur, and a score less than 3 is unlikely to occur (Shiwakoti et al., 2016; Greene, 2002).

For the same set of behaviour, such as the four strategies of pre-evacuation, the form of pairwise comparison is taken to compare the relative importance of the different strategies. In addition, based on whether the sample data satisfies the normal distribution, the paired sample T-test or the non-parametric test is selected to check whether there is a significant difference between the sample data. If the null hypothesis that there is no clear difference between the strategies is rejected, there are significant differences between the sample data, and the strategy with a larger average is more likely to occur (Shiwakoti et al., 2017; 2016).

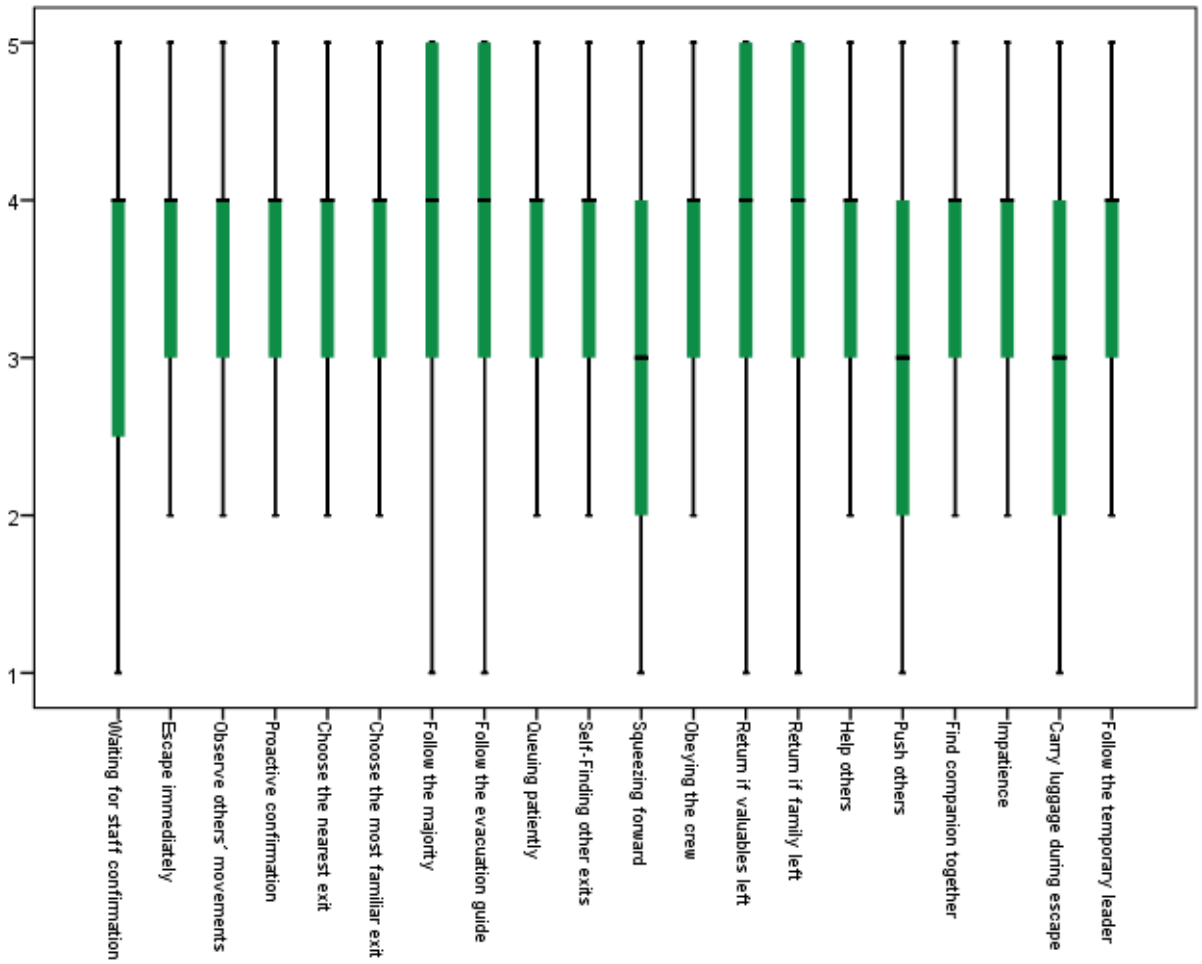
To better understand the differences between demographic characteristics and likely behaviours, a series of logistic regression analyses were performed on the 5-point Likert scale based on the dependent and independent variable types. In the ordinal logistic regression, it is assumed that the coefficients of the independent variables in several binary logistic regressions are equal, and it is necessary to test the hypothesis that the coefficients of the independent variables are equal (also called a parallel line test). If this assumption is not met, a multinomial logistic regression model is considered to be used. Multinomial logistic regression is one of the

most commonly used econometric models to generalize logistic regression to multiple types of problems. Specifically, it is a model used to predict the probability of a given set of independent variables affecting the possible outcomes of the dependent variable (Stoneman et al., 2019; Weng et al., 2019).

4 Results

Many studies have used statistical methods to investigate personnel's selection behaviour in emergency situations, and provide numerical analysis results based on statistical models, which have provided references for this study (Orlov and Kallbekken, 2019; Shiwakoti et al., 2019a; 2017; Ahola and Mugge, 2017; Haghani and Sarvi, 2016; Hatfield and Prabhakharan, 2016; Basha and Maiti, 2013). It is generally believed that Cronbach's alpha coefficient is very good when the score is between 0.8 and 0.9 (Sun et al., 2019). Based on statistics analysis, the Cronbach's alpha coefficient of this questionnaire is 0.881, which is between 0.8 and 0.9, indicating that the reliability of the questionnaire is very good. The questionnaire is designed based on literature research, practical analysis and expert interview. Therefore, only a structural validity analysis is carried out. The KMO value of this survey is 0.87, and the Sig value of BTS is $P<0.01$, indicating that there are correlations between the variables.

The box plot of Fig. 1 shows the distribution of each likely behaviour of the respondents, from which it is easy to see how close the behaviour selection data is to the neutral value or extreme value. Table 2 summarizes the distribution of each behavioural strategy. Since the sample data does not obey a normal distribution, a series of Wilcoxon single-sample tests were performed for each likely behaviour. At the 99% confidence level, all test results ($p<0.001$, refer to appendix B-Table B1) reject the null hypothesis that the mean is equal to the neutral value of 3. Given that a score greater than 3 is likely to occur, and a score less than 3 is unlikely to occur if the null hypothesis is rejected, from Table 2, it can be therefore concluded, on average, that passengers tend to perform all the behaviours investigated.



Note: 1="Very Unlikely" to 5="Very Likely"

Fig.1. Box plots of passenger's behaviour

For the internal comparative analysis of likely behaviours in the criteria of pre-evacuation behaviour, path-finding behaviour, and behaviour at exit congestion, each of the three groups has four strategies and a correction for multiple comparisons should be considered (Shiwakoti et al., 2019a; Curtin and Schulz, 1998). For instance, for the four questions on pre-evacuation in the questionnaire, all possible pairwise comparisons were considered to establish if the answers to these questions were different (Curtin and Schulz, 1998). The Bonferroni correction of every group's strategies is showed in Table 3.

At the 95% confidence level, the tests of the null hypothesis (i.e. that there is no clear difference) were rejected for all of these pairwise comparisons, except for comparative analysis of QA1-QA2, QA3-QA4, QB1-QB2, QB2-QB3 and QC1-QC4. For the pre-evacuation

behaviour, there is no statistically significant difference between QA3 and QA4, and between QA1 and QA2. However, there are statistically significant differences between QA1 and QA3, between QA1 and QA4, between QA2 and QA3, and between QA2 and QA4. Considering that a higher average score in the survey response implies that passengers are more likely to follow this behaviour if the null hypothesis is rejected, it is suggested that QA3 and QA4 are statistically more likely than QA1 and QA2. Therefore, it can be concluded from Table 2 and Table 3 that in the pre-evacuation behaviour, passengers tend to proactively respond to evacuation alarms, and observe others' actions, rather than waiting for the staff to decide or escape immediately. In the path-finding behaviour, passengers tend to follow the evacuation PA or instructions, rather than choosing the nearest exit or most familiar exit. When the exit is congested, passengers tend to choose to follow the crew's guidance and wait patiently, rather than rushing forward or self-finding other exits. Furthermore, the Wilcoxon signed-rank test was used to detect the internal comparative analysis in the groups of counter flow behaviour, and competition and cooperative behaviour of which there were no multiple comparisons. At the 99% confidence level, the tests ($p<0.001$, refer to appendix B-Table B2) of the null hypothesis were rejected, which means that there is a clear difference between the compared strategies. It can be concluded from Table 2, in the case of counter flow behaviour, when the family is left behind, the passengers are more likely to return. In competition and cooperation, passengers tend to assist others in evacuation rather than competing with others.

Table 2

Summary of passenger's likely behaviour on Ro-Ro passenger ship

Question NO.	Variables	Very Unlikely	Unlikely	Neutral	Likely	Very Likely	Mean	SD
QA	*Pre-evacuation behaviour*							
QA1	Waiting for staff confirmation	11.5	13.5	24.3	32.7	18	3.32	1.24
QA2	Escape immediately	8.0	13.5	27.4	38.0	13.1	3.35	1.11
QA3	Observe others' movements	6.8	11.2	22.8	43.8	15.3	3.50	1.09
QA4	Proactive confirmation	5.1	12.2	20.1	42.6	19.9	3.60	1.09
QB	*Path-finding behaviour*							
QB1	Choose the nearest exit	3.9	13.3	21.7	38.8	22.2	3.62	1.09
QB2	Choose the most familiar exit	3.0	11.2	21.3	39.9	24.6	3.72	1.05
QB3	Follow the majority	2.4	11.7	20.9	39.6	25.4	3.74	1.04
QB4	Follow the evacuation guide or PA	2.5	13.4	16.2	34.9	33.0	3.83	1.11
QC	*Behaviour during exit congestion*							
QC1	Queuing patiently	3.6	12.8	20.6	39.1	23.9	3.67	1.08
QC2	Self-Finding other exits	3.0	13.8	28.0	37.9	17.2	3.53	1.03
QC3	Squeezing forward	9.1	27.2	22.2	25.4	16.2	3.12	1.23
QC4	Obeying the crew	3.6	9.2	21.1	42.1	24.1	3.74	1.04
QD	*Counter flow behaviour*							

QD1	Return when valuables left behind	6.2	13.6	23.3	28.4	28.5	3.60	1.21
QD2	Return when family left behind	3.8	12.0	19.2	29.3	35.8	3.81	1.15
QE	*Competition and cooperation behaviour*							
QE1	Help others	3.1	12.9	25.1	40.7	18.3	3.58	1.03
QE2	Push others	8.6	24.1	23.3	26.8	17.2	3.20	1.23
QF	*Group behaviour*							
QF1	Find companion to escape together	2.8	10.2	19.7	47.7	19.6	3.71	0.99
QG	*Impatient behaviour*							
QG1	Impatience	2.5	13.6	20.5	40.9	22.5	3.67	1.05
QH	*Carrying luggage*							
QH1	Carry luggage during escape	9.8	23.3	26.1	24.6	16.2	3.14	1.23
QI	*Temporary leadership behaviour*							
QI1	Follow the temporary leader	3.3	13.3	26.7	36.8	19.9	3.57	1.05

Table 3

The p-values and test statistic of multiple comparison

Group		Test Statistic	Std. Error	Std. Test Statistic	Sig.
QA1	QA2	15.178	58.163	0.261	0.794
	QA3	-199.832	58.163	-3.436	0.001*
	QA4	-344.058	58.163	-5.915	<0.001*
QA2	QA3	-215.01	58.163	-3.697	<0.001*
	QA4	-359.236	58.163	-6.176	<0.001*
QA3	QA4	-144.226	58.163	-2.48	0.013
QB1	QB2	-127.742	58.055	-2.2	0.028
	QB3	-155.351	58.055	-2.676	0.007*
	QB4	-322.081	58.055	-5.548	<0.001*
QB2	QB3	-27.608	58.055	-0.476	0.634
	QB4	-194.338	58.055	-3.347	0.001*
QB3	QB4	-166.73	58.055	-2.872	0.004*
QC1	QC2	235.269	58.453	4.025	<0.001*
	QC3	715.364	58.453	12.238	<0.001*
	QC4	-91.812	58.453	-1.571	0.116
QC2	QC3	480.095	58.453	8.213	<0.001*
	QC4	-327.081	58.453	-5.596	<0.001*
QC3	QC4	-807.176	58.453	-13.809	<0.001*

Note: * statistically significant difference with $p < 0.008(0.5/6)$, incorporating a Bonferroni correction.

To explore the demographic differences of the likely behaviours, using demographic variables as independent variables, and likely behaviours as dependent variables, a series of multinomial logistic regression models were established using Equation 1. Categorical variables, such as gender, are treated as dummy variables before analysis. Following this, the demographic data was put into the model, the quality of the models was tested, and the likelihood ratio was used to check the variable significance in the model. Subsequently, all the obtained values were smaller than 0.05 ($p<0.05$). The original hypothesis that the model has the same quality before and after inserting the independent variables was rejected, indicating that the model is effective, and the model construction is reasonable. Finally, the influence of certain demographic factors on each likely behaviour is analysed under the common influence of demographic data.

The regression coefficient can explain the influence level of the factors. A positive number indicates a positive influence, and a negative number indicates a negative influence. The magnitude of the influence can be expressed by the odd ratio (OR), as shown in Equation 2, which means that an independent variable is increased by one unit, and the dependent variable is increased or decreased, when the influence of other independent variables is excluded.

$$\Pr\{Y_i = j \mid X_i\} = \frac{e^{\beta_j X_i}}{1+\sum_{k=1}^{J} e^{\beta_k X_i}} \qquad j=1\ldots, k\text{-}1, \beta_0 = 0 \qquad (1)$$

$$OR_j = \exp(\beta_j) \qquad (2)$$

If the dependent variables have *k* categories, the multinomial logistic regression model will establish *k-1* generalized superiority models and select one of them as the reference. Where *i* is an index for independent variables, *j* is an index of different categories of a dependent variable, Y_i represents the dependent variable vector, X_i represents the independent variable vector, and β_j represents the regression coefficient vector. The dependent variable is a selected level of likely behaviour and independent variables are the demographic characteristics (Greene, 2002; Orlov and Kallbekken, 2019).

Statistical analysis was performed based on the results of a series of multinomial logistic regression models with different likely behaviours. In the analysis of each multinomial logistic regression, grade "1" (Very Unlikely) was chosen as the reference, and each comparative analysis was performed with "1" (Very Unlikely) as the reference. For the category *gender*, it is treated as a dummy variable before analysis, and male (man) was taken as reference. The multinomial logistic regression analysis of the likely behaviour QD2 (Return when family is left behind) is shown in Table 4, and the results of the multinomial logistic regression for other likely behaviours are presented in the discussion. It can be clearly found that at the 90% confidence level, the age group, education level and mobility have significantly affected passengers' QD2 behaviour. The correlation coefficient between age group, mobility and QD2

behaviour is positive, indicating that passengers are more likely to have QD2 behaviour as the age group increases and their mobility increases. The correlation coefficient between education level and QD2 behaviour is negative, indicating that as the education level increases, and the possibility of QD2 behaviour is gradually reduced. However, it cannot be concluded that people with higher education levels are more rational, as the rationality of passenger performance requires a reference point, such as individualistic optimum or social optimum (Haghani et al. 2019b). For some passengers, the safety of their relatives may be more important than their own or collective evacuees'.

Table 4

Result of multinomial logistic regression on likely behaviour QD2

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.179	0.096	0.062	1.196
	3	0.235	0.091	0.010	1.265
	4	0.160	0.089	0.072	1.173
	5	0.232	0.089	0.009	1.261
Gender (Women vs man)	2	-0.245	0.338	0.468	0.783
	3	-0.123	0.325	0.705	0.885
	4	-0.37	0.314	0.239	0.691
	5	-0.353	0.313	0.259	0.703
Education level	2	-0.498	0.19	0.009	0.608
	3	-0.581	0.182	0.001	0.559
	4	-0.337	0.175	0.054	0.714
	5	-0.389	0.174	0.026	0.678
Mobility	2	0.566	0.16	<0.001	1.761
	3	0.574	0.152	<0.001	1.775
	4	0.619	0.147	<0.001	1.857
	5	0.653	0.148	<0.001	1.922
Experience on board	2	0.024	0.27	0.929	1.024
	3	-0.307	0.258	0.234	0.735
	4	-0.179	0.249	0.473	0.836
	5	0.364	0.249	0.143	1.439
The number of people travelling together	2	0.118	0.204	0.564	1.125
	3	0.257	0.196	0.19	1.293
	4	0.017	0.189	0.928	1.017
	5	-0.001	0.187	0.996	0.999
Evacuation education or training experience	2	-0.049	0.173	0.778	0.952
	3	-0.198	0.166	0.233	0.82
	4	-0.155	0.16	0.335	0.857
	5	-0.100	0.159	0.531	0.905

Note: The reference category is 1 (Very Unlikely).

5 Discussion

Ship evacuation is affected by many different factors, such as the number of passengers and the demographic characteristics of passengers (Vanem and Skjong, 2006). The IMO's guideline explains in detail the variables that affect the evacuation of passenger ships, and guides member states in conducting evacuation analysis studies. Based on the gender and age

of the evacuees, the guideline gives maximum and minimum speeds for walking on flat areas and staircase areas (divided into travelling up and down stairs). However, the values of each variable are estimated by the IMO according to the data submitted by the member states. Due to the different race, cultural background and education level of sample data, the IMO still needs to carry out a large number of experiments and investigations to collect human behaviour data during emergency evacuation, and optimize ship evacuation algorithms and models (IMO, 2016; Lu and Liang, 2012).

Table 5
Population's composition (age and gender) of this survey compared with the guideline

Population groups – passengers	The Guideline	This Survey
Females younger than 30 years	7%	29%
Females 30-50 years old	7%	16%
Females older than 50 years	16%	10%
Females older than 50, mobility impaired (1)	10%	3%
Females older than 50, mobility impaired (2)	10%	
Males younger than 30 years	7%	21%
Males 30-50 years old	7%	13%
Males older than 50 years	16%	6%
Males older than 50, mobility impaired (1)	10%	2%
Males older than 50, mobility impaired (2)	10%	

The comparison of the passenger composition of this survey with the recommendations of the IMO guideline is shown in Table 5. As stated by Lu and Liang (2012), the composition of passengers varies by region, ethnicity, and cultural background. It can be clearly seen that the population composition of the IMO guideline is significantly different from this survey. The passenger composition recommended by the IMO is the average level of the member states, and the data provided by a member state may represent the domestic average level. When analysing the passenger composition of a certain ship route or region, a targeted survey is proposed to find out whether there are any differences between theoretical recommendation and the actual situation, and then study the impact of passenger composition on evacuation results.

5.1 Pre-evacuation

Given that a higher average score in the survey response implies that passengers are more likely to follow this behaviour if the null hypothesis is rejected, the test results of the non-

parametric test and multiple comparisons show that during the pre-evacuation of the passenger ship, passengers are more likely to respond proactively or observe others' actions rather than passively when waiting for the staff to confirm or escape immediately. As shown in Table 6, the multinomial logistic regression results show that for the QA4 strategy (Proactive confirmation), the correlation coefficients between the mobility and the experience of evacuation education are negative, and the rest are positive. When compared to the condition of Very Unlikely, under the condition of Very Likely, the age, mobility, experience on board and the number of people travelling together are statistically significant under the 95% confidence level, indicating that the pre-evacuation behaviour of passengers is affected statistically significant by these factors. The correlation coefficient of the age group is 0.217 ($p=0.019$), which suggests that the age group might have a statistically significant positive association with the QA4 strategy, and the OR is 1.242. In other words, there is a possibility that, as the age increases, the probability of passengers choosing the QA4 strategy may gradually increase. Moreover, for each additional unit in the age group, the possibility of choosing the QA4 strategy increases by 1.242 times. This impact analysis is also applied to the rest of the discussion section. The correlation coefficient of the mobility to act is -0.379 ($p=0.002$), which indicates that there were statistically significant negative interaction effects between mobility and the QA4 strategy, with an OR of 0.672.

The correlation coefficient of the experience on board is 0.77 ($p=0.001$), which indicates that the experience on board will have a statistically significant positive relationship with the QA4 strategy, and the OR value is 2.16. The correlation coefficient of the number of people travelling together is 0.842 ($p<0.001$), which means that the number of people travelling together will have a statistically significant positive impact on the QA4 strategy, and the OR is 2.32. Compared to "age group", the influence degree of "the number of people travelling together" on the QA4 strategy is greater, most likely due to the fact that people who are part of

a large group are more concerned about safety-related issues and have a higher level of safety awareness (Hurley, 2016).

Table 6

Result of multinomial logistic regression on likely behaviour QA4

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.101	0.096	0.29	1.106
	3	0.137	0.092	0.135	1.147
	4	0.281	0.088	0.001	1.324
	5	0.217	0.093	0.019	1.242
Gender (Women vs man)	2	0.414	0.297	0.164	1.513
	3	0.429	0.286	0.134	1.536
	4	0.275	0.27	0.31	1.316
	5	0.169	0.288	0.558	1.184
Education level	2	0.215	0.184	0.242	1.24
	3	0.098	0.177	0.582	1.102
	4	0.1	0.168	0.55	1.106
	5	0.194	0.179	0.278	1.214
Mobility	2	-0.306	0.131	0.019	0.736
	3	-0.493	0.128	<0.001	0.611
	4	-0.264	0.12	0.027	0.768
	5	-0.397	0.131	0.002	0.672
Experience on board	2	0.081	0.232	0.729	1.084
	3	0.365	0.224	0.103	1.441
	4	0.408	0.209	0.050	1.504
	5	0.77	0.226	0.001	2.16
The number of people travelling together	2	0.687	0.199	0.001	1.988
	3	0.896	0.19	<0.001	2.451
	4	0.68	0.18	<0.001	1.974
	5	0.842	0.19	<0.001	2.32
Evacuation education or training experience	2	-0.209	0.172	0.226	0.812
	3	-0.095	0.164	0.56	0.909
	4	-0.061	0.156	0.698	0.941
	5	-0.064	0.165	0.699	0.938

Note: The reference category is 1 (Very Unlikely).

During the evacuation of land-based transportation facilities, passengers are more likely to choose a passive strategy. Even if they hear an evacuation alarm, they tend to wait for staff's confirmation (Shiwakoti et al., 2017; Fridolf et al., 2013). Ship passenger evacuation studies showed that 83% of people chose to proactively verify the accuracy of the alarm after hearing the evacuation alert (Casareale et al., 2017), which is similar to the results of this study (62.5%), indicating the safety alert of the ship's passengers is stronger. After hearing the evacuation alarm, they are more likely to proactively confirm the authenticity of the incident. This may be related to the situation where ship passengers are not familiar with the ship environment and have higher safety awareness; however, this kind of proactive behaviour and its impact on the people nearby may benefit evacuation efficiency (Haghani et al. 2019b). Moreover, this feature is significantly affected by factors such as age group, mobility, experience on board and the number of people travelling together. Passengers who are elderly, with limited mobility, have

more experience on board and are part of a larger number of people travelling together are more likely to actively confirm the incident.

Similar to the results in the literature (Bode et al., 2019; 2015a; 2015b; 2013; Proulx et al., 1995; Horasen and Bruck, 1994), this study did not find significant differences in the pre-evacuation behaviour between men and women. However, similar to the above studies, this study found that passengers are also more likely not to choose to evacuate immediately. Therefore, it is inappropriate not to consider the pre-evacuation behaviour of passengers in some current evacuation studies, and the calculated evacuation time is not accurate enough (Haghani et al., 2019a; Hurley, 2016; Nevalainen, 2015). The results of this study also support some mathematical models or standpoints in the simulation study that consider the loss of the initial time of evacuation. In the analysis of pre-evacuation behaviour, some researchers argue that the individual's familiarity with the environment is an important factor in determining the delay of action, but this kind of delay has different opinions on a positive or negative impact of the overall evacuation time (Bode and Codling, 2019; Haghani et al. 2019a; 2019b). It is recommended that experimental research should be carried out to collect data on the pre-evacuation behaviour and reaction time of passengers and provide support for current evacuation modelling.

5.2 Path-finding behaviour

Given that a higher average score in the survey response implies that passengers are more likely to follow this behaviour if the null hypothesis is rejected, the test results of the nonparametric test and multiple comparisons show that, in the category path-finding, the passengers are more likely to choose the QB4 (Follow the evacuation guide or PA) strategy. In the QB4 strategy, the proportion of passengers who chose Likely or Very Likely is as high as 67.9%, which also shows the importance of the crew's guidance on evacuating passengers. In the QB3 (Follow the majority) strategy, the proportion of passengers who chose Likely or Very

Likely is as high as 65%, confirming the phenomenon of "herding behaviour" or "imitation behaviour" (Haghani et al. 2019b) during evacuation. As shown in Table 7, the multinomial logistic regression results show that for the QB4 strategy, the correlation coefficients of age group, gender, mobility, and the number of people travelling together are positive. At a 95% confidence level, when compared to the condition of Very Unlikely, the significance of the age group is statistical significant under the condition of Very Likely, and the correlation coefficient is 0.363 ($p<0.001$). This indicates that there are statistically significant positive relationships between the age group and the QB4 strategy. Similarly, the OR for this analysis is 1.438.

Table 7

Result of multinomial logistic regression on likely behaviour QB4

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.078	0.109	0.471	1.082
	3	0.08	0.107	0.453	1.084
	4	0.186	0.103	0.071	1.204
	5	0.363	0.104	<0.001	1.438
Gender (Women vs man)	2	0.404	0.377	0.284	1.498
	3	0.388	0.372	0.296	1.474
	4	0.247	0.358	0.489	1.281
	5	0.151	0.36	0.675	1.163
Education level	2	-0.043	0.226	0.849	0.958
	3	0.215	0.222	0.333	1.239
	4	0.034	0.214	0.875	1.034
	5	-0.185	0.215	0.39	0.831
Mobility	2	0.731	0.184	<0.001	2.076
	3	0.59	0.182	0.001	1.803
	4	0.774	0.176	<0.001	2.169
	5	0.83	0.178	<0.001	2.293
Experience on board	2	-0.414	0.296	0.161	0.661
	3	-0.35	0.292	0.231	0.705
	4	-0.447	0.281	0.112	0.639
	5	-0.079	0.283	0.781	0.924
The number of people travelling together	2	0.075	0.226	0.741	1.078
	3	0.361	0.223	0.106	1.435
	4	0.288	0.214	0.179	1.334
	5	0.289	0.215	0.178	1.335
Evacuation education or training experience	2	-0.272	0.201	0.177	0.762
	3	-0.405	0.199	0.041	0.667
	4	-0.211	0.19	0.268	0.81
	5	-0.064	0.191	0.738	0.938

Note: The reference category is 1 (Very Unlikely).

For another likely behavioural strategy QB3, as shown in Table 8, the correlation coefficients of age group, mobility, and the number of people travelling together are positive while the rest are negative. At the 95% confidence level, age group, gender, number of people travelling together, and experience of evacuation education were statistically significant. When compared to the condition of Very Unlikely, the correlation coefficient for the age group is 0.539 ($p<0.001$) under the condition of Very Likely, which indicates that the age group is

statistically significantly correlated positively with the QB3 strategy, and an OR of 1.715. The correlation coefficient of gender is -1.071 ($p=0.018$), which suggests that gender has a statistically significant negative impact on the QB3 strategy, where the OR is 0.343. The correlation coefficient of the number of people travelling together is 0.916 ($p<0.001$), which indicates that the number of people travelling together has a statistically significantly positive link with the QB3 strategy, and the OR is 2.498. The correlation coefficient of the experience of evacuation education is -0.372 ($p=0.05$), which shows that the experience of evacuation education has a statistically significant negative impact on the QB3 strategy, and the OR value is 0.689. Similar to the QA4 strategy, the influence degree of "the number of people travelling together" on the QB3 strategy is greater than others.

Table 8

Result of multinomial logistic regression on likely behaviour QB3

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.376	0.139	0.007	1.456
	3	0.452	0.134	0.001	1.571
	4	0.527	0.133	<0.001	1.694
	5	0.539	0.134	<0.001	1.715
Gender (Women vs man)	2	-1.109	0.466	0.017	0.33
	3	-1.047	0.455	0.021	0.351
	4	-1.088	0.449	0.015	0.337
	5	-1.071	0.454	0.018	0.343
Education level	2	-0.078	0.238	0.742	0.925
	3	0.104	0.228	0.647	1.11
	4	-0.134	0.224	0.549	0.874
	5	-0.009	0.228	0.97	0.991
Mobility	2	0.428	0.182	0.019	1.535
	3	0.255	0.176	0.148	1.291
	4	0.401	0.173	0.021	1.493
	5	0.357	0.178	0.044	1.43
Experience on board	2	-0.326	0.297	0.272	0.722
	3	-0.207	0.287	0.471	0.813
	4	-0.163	0.281	0.561	0.85
	5	-0.104	0.288	0.718	0.901
The number of people travelling together	2	0.482	0.232	0.038	1.619
	3	0.673	0.222	0.002	1.96
	4	0.75	0.217	0.001	2.117
	5	0.916	0.221	<0.001	2.498
Evacuation education or training experience	2	-0.58	0.205	0.005	0.56
	3	-0.566	0.196	0.004	0.568
	4	-0.514	0.191	0.007	0.598
	5	-0.372	0.195	0.05	0.689

Note: The reference category is 1 (Very Unlikely).

In an emergency, the path-finding behaviour of the person is driven by the instinct to keep away from danger. A person's choice is related to factors such as personal experience and familiarity with the environment. The first is the individual's perception of the evacuation environment, such as familiarity (Lovreglio et al., 2016), exit affordability (Haghani et al. 2016)

and safe location (Haghani et al. 2019a), which significantly influence the decision-making and behaviour of individuals in selecting an exit route in an emergency (Hurley, 2016; Nevalainen, 2015). Similar to the literature research above, this research shows that when selecting the evacuation path, people prefer to rely on evacuation indication or PA, i.e., static or dynamic evacuation indication. Studies have also shown that compared to static guidance systems, in the case of high pressure, it is easy for people to misunderstand static evacuation instructions. The main help for passengers is dynamic guidance, or mutual help between personnel (Galea et al., 2017; Kvamme, 2017; Lovreglio et al., 2016).

The research results show that people tend to follow others and show herding behaviour, however, the path-finding behaviour is the result of a combination of multi-attribute factors. The impact of other factors still needs to be considered, such as the distance from the exit and the degree of congestion (Shiwakoti et al., 2017; Haghani et al. 2016; Lovreglio et al., 2016). Some studies have shown that most people do not show herding behaviour in an emergency; in contrast, they tend to avoid joining crowded people (Haghani et al. 2019a; 2019b; 2019c). However, when the exit is not visible, there is a higher possibility of herding behaviour (Haghani and Sarvi, 2016). According to a survey conducted by Casareale et al. (2017), 76% of passengers said they would follow the given advice during the path-finding. Similarly, this survey shows that the proportion of passengers who choose Likely or Very Likely in the QB3 strategy is as high as 65%, indicating that the proportion of people who choose to follow others during the emergency evacuation process is higher. This may be related to the phenomenon that people are less familiar with the ship. Unlike the study of Shiwakoti et al. (2017), that men are more likely to show risky behaviours, however, this survey shows that men are more likely to show herding behaviour.

5.3 Choice behaviour when there is exit congestion

Currently, the majority of research regarding passenger evacuation focuses on the exit

615 design and exit idleness (Shiwakoti et al., 2017; Hurley, 2016; Lee et al., 2003; Glen et al.,
616 2001). Given that a higher average score in the survey response implies that passengers are
617 more likely to follow this behaviour if the null hypothesis is rejected, the results of the
618 nonparametric test and multiple comparisons show that, in general, when the exit is congested,
619 the passenger is more likely to choose the QC4 (Obeying the crew) and QC1 (Queuing patiently)
620 strategies, and finally the QC3 (Squeezing forward) strategy. Among the passengers who chose
621 Likely or Very Likely, the proportion of the QC4 strategy is as high as 66.2%, indicating the
622 degree of passenger dependence on the crew when the exit is congested, and the proportion of
623 the QC1 strategy is 63.0%, while the QC3 strategy is only 41.6%, indicating that passengers
624 are more likely to be patiently waiting for evacuation, not forcing forward. As shown in Table
625 9, the multinomial logistic regression results show that the mobility is statistically significant
626 at the 95% confidence level. When compared to the condition of Very Unlikely, the correlation
627 coefficient of mobility is 0.678 ($p<0.001$) under the condition of Very Likely, suggesting that
628 statistically significant positive interactive effects between mobility and the QC4 strategy, with
629 an OR of 1.97.

630
631

Table 9

Result of multinomial logistic regression on likely behaviour QC4

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.101	0.103	0.327	1.106
	3	0.174	0.095	0.067	1.19
	4	0.382	0.093	<0.001	1.466
	5	0.356	0.094	<0.001	1.428
Gender (Women vs man)	2	-0.202	0.356	0.570	0.817
	3	-0.338	0.331	0.307	0.713
	4	-0.325	0.323	0.314	0.722
	5	-0.413	0.328	0.209	0.662
Education level	2	-0.073	0.204	0.720	0.93
	3	-0.089	0.189	0.636	0.915
	4	-0.122	0.183	0.505	0.885
	5	0.005	0.186	0.977	1.005
Mobility	2	0.529	0.172	0.002	1.697
	3	0.75	0.162	<0.001	2.118
	4	0.985	0.159	<0.001	2.678
	5	0.678	0.161	<0.001	1.97
Experience on board	2	-0.362	0.282	0.199	0.696
	3	-0.425	0.262	0.105	0.654
	4	-0.351	0.255	0.168	0.704
	5	-0.079	0.259	0.762	0.924
The number of people travelling together	2	0.103	0.21	0.624	1.109
	3	0.139	0.195	0.476	1.149
	4	0.117	0.189	0.537	1.124
	5	0.1	0.192	0.602	1.105
Evacuation education or	2	-0.197	0.18	0.274	0.821
	3	-0.332	0.168	0.048	0.717

training	4	-0.296	0.162	0.068	0.744
experience	5	-0.088	0.165	0.595	0.916

Note: The reference category is 1 (Very Unlikely).

For the QC1 strategy, as shown in Table 10, the correlation coefficients of the age group, mobility and the number of people travelling together are positive while the others are negative. When compared to the condition of Very Unlikely, the correlation coefficient between the experience on board and the experience of evacuation education under the condition of Likely is -0.448 (*p=0.063*) and -0.237 (*p=0.141*), respectively, indicating that as the experience on board and the experience of evacuation education increases, the likelihood of passengers choosing the QC1 strategy is reduced. At the 90% confidence level, the number of people travelling together is statistically significant. When compared to the condition of Very Unlikely, the correlation coefficient of number of people travelling together is 0.318 (*p=0.081*) under the condition of Very Likely, which indicates that the number of people travelling together will have a statistically significant positive impact on the QC1 strategy, with an OR of 1.374.

Table 10

Result of multinomial logistic regression on likely behaviour QC1

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.029	0.101	0.771	1.03
	3	0.164	0.096	0.088	1.178
	4	0.271	0.093	0.004	1.311
	5	0.34	0.095	<0.001	1.406
Gender (Women vs man)	2	-0.194	0.342	0.570	0.823
	3	-0.114	0.328	0.729	0.893
	4	-0.347	0.318	0.274	0.706
	5	-0.399	0.325	0.219	0.671
Education level	2	-0.289	0.196	0.141	0.749
	3	-0.073	0.185	0.693	0.93
	4	-0.355	0.179	0.048	0.701
	5	-0.13	0.183	0.475	0.878
Mobility	2	0.327	0.158	0.038	1.387
	3	0.284	0.152	0.061	1.329
	4	0.548	0.148	<0.001	1.73
	5	0.436	0.152	0.004	1.547
Experience on board	2	-0.458	0.262	0.08	0.633
	3	-0.358	0.249	0.151	0.699
	4	-0.448	0.241	0.063	0.639
	5	-0.167	0.247	0.500	0.846
The number of people travelling together	2	0.363	0.196	0.064	1.438
	3	0.387	0.186	0.037	1.473
	4	0.349	0.179	0.051	1.418
	5	0.318	0.182	0.081	1.374
Evacuation education or training experience	2	-0.436	0.176	0.013	0.647
	3	-0.463	0.167	0.006	0.63
	4	-0.237	0.161	0.141	0.789
	5	-0.065	0.164	0.692	0.937

Note: The reference category is 1 (Very Unlikely).

In terms of vessel design, simply arguing that ship layout and emergency indication

signals are sufficient to guide passengers or assist in choosing a reasonable exit is not convincing (Casareale et al., 2017). Similar to the findings of path-finding behaviour, when exit is congested, passengers will rely strongly on the crew's guidance instructions for exit selection. The following statement is also true, that the older the passenger, the higher the degree of dependence in an evacuation. Furthermore, in the absence of crew guidance, passengers tend to choose to wait patiently, and the larger the number of people travelling together, the more likely they are to choose the QC1 strategy. However, the greater the passengers experience on board and evacuation education, the less likely they are to choose the QC1 strategy. This shows that personal experience can improve people's decision-making ability to deal with risks, reduce the possibility of cognitive paralysis, and reduce conservative attitudes. One-sided cognition brings unfavourable behaviours, such as preferring to wait patiently and not trying to find other exits, causing an exit to be too congested, while other favourable exits are idle (Kvamme, 2017). Consequently, the ship designer should optimize a static guidance system such as graphic indication signs and sound guidance. Ship managers should set up guidance personnel at key locations where crowding or bottlenecking may occur, and guide passengers to evacuate through gestures and voice commands, minimizing the possibility of idle exits.

5.4 Counter flow behaviour

The results of the non-parametric test show that, relatively speaking, passengers were more likely to return when their family left. The proportion of the QD1 (Return when valuable left behind) and QD2 (Return when family left behind) strategies among passengers who chose Likely or Very Likely is as high as 56.9% and 65.1%, respectively. For the QD2 strategy, as shown in Table 4, the correlation coefficients for age group, mobility, and the number of people travelling together are positive while the rest are negative. At the 90% confidence level, the age, education level, and mobility are statistically significant. When compared to the condition

of Very Unlikely, under the condition of Very Likely, the correlation coefficient for the age group is 0.232 ($p=0.009$), which suggests that the age group has a statistically significant positive relationship with the QD2 strategy where the OR is 1.261. The correlation coefficient of education level is -0.389 ($p=0.026$), which indicates that there is a statistically significant negative relationship between education level and the QD2 strategy where the OR is 0.678. The correlation coefficient of mobility is 0.653 ($p<0.001$), which suggests that the mobility to act will have a statistically significant positive impact on the QD2 strategy, with an OR of 1.922.

During the evacuation process, the typical counter flow avoidance behaviour is that passengers return to the cabin to find families or valuables. For example, in the "Costa Concordia" accident, a passenger spent 1.5 hours finding his daughter (Kvamme, 2017). This study supports the existence of the phenomenon, especially in the case of left-behind families, that the possibility of passengers choosing to turn back is relatively high. For demographic differences in counter flow behaviour, older passengers, with better mobility and a large number of people travelling together, the greater the likelihood of choosing the QD2 strategy. As people have different levels of attachment to relatives or valuables, it is generally dependent on the type of each individual in terms of turning back (Bode and Codling, 2019). However, the higher the level of education, the less likely it is for a passenger to choose the QD2 strategy. To reduce the adverse impact of the counter flow behaviour on evacuation, the ship manager should pay more attention to the volume of old people travelling, and should guide them to avoid returning to the cabin as much as possible.

5.5 Competition and cooperation behaviour

The results of the non-parametric test show that, compared to competitive behaviour, passengers are more likely to show cooperative behaviour. In the QE1 (Help others) strategy, the proportion of passengers who choose Likely or Very Likely is 59%, and the proportion of passengers who choose Unlikely or Very Unlikely is only 16%. As shown in Table 11, the

results of the multinomial logistic regression model shows that the correlation coefficients between age group, mobility and the number of people travelling together are positive while the rest are negative. When compared to the condition of Very Unlikely, the age group correlation coefficient is 0.207 (*p=0.04*) under the condition of Very Likely, which indicates that the age group has a statistically significant positive association with the QE1 strategy, and the OR is 1.23. The correlation coefficient of the number of people travelling together is 0.460 (*p=0.018*), which suggests that the number of people travelling together is statistically significantly correlated positively with the QE1 strategy, and the OR is 1.584.

Table 11

Result of multinomial logistic regression on likely behaviour QE1

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	0.165	0.104	0.110	1.18
	3	0.208	0.099	0.036	1.231
	4	0.206	0.098	0.035	1.229
	5	0.207	0.101	0.04	1.23
Gender (Women vs man)	2	-0.01	0.351	0.978	0.99
	3	0.229	0.337	0.496	1.258
	4	-0.145	0.329	0.659	0.865
	5	-0.262	0.34	0.442	0.77
Education level	2	-0.384	0.203	0.058	0.681
	3	-0.396	0.193	0.040	0.673
	4	-0.248	0.188	0.187	0.78
	5	0.04	0.194	0.836	1.041
Mobility	2	0.156	0.166	0.346	1.169
	3	0.399	0.16	0.012	1.491
	4	0.507	0.156	0.001	1.661
	5	0.234	0.162	0.149	1.264
Experience on board	2	-0.092	0.27	0.734	0.913
	3	-0.425	0.26	0.101	0.654
	4	-0.353	0.253	0.163	0.702
	5	-0.198	0.264	0.452	0.82
The number of people travelling together	2	0.151	0.201	0.451	1.163
	3	0.419	0.193	0.030	1.521
	4	0.392	0.187	0.036	1.48
	5	0.46	0.195	0.018	1.584
Evacuation education or training experience	2	-0.395	0.182	0.030	0.674
	3	-0.398	0.173	0.022	0.672
	4	-0.41	0.169	0.016	0.664
	5	-0.26	0.176	0.139	0.771

Note: The reference category is 1 (Very Unlikely).

Similar to the findings of Shiwakoti et al. (2017), this study did not find gender differences in the behaviour of helping others. However, it is found that the older the passengers and the larger number of people travelling together, the more likely they are to help others. This may be due to the stronger social cognition of the seniors and the mutual trust between people in the group (Ahola et al., 2014). However, it is worth noting that some researchers argue that the cooperation and competitive behaviour between passengers is related to the nature and extent

of the danger. In non-emergency situations, passengers cannot truly perceive the urgency and seriousness of the danger; therefore, they tend to choose a cooperative strategy rather than a competitive one (Shiwakoti et al., 2017). As the results of this survey show, for competitive behaviour, 44% of passengers choose Likely or Very Likely, and for cooperative behaviour, 16% of passengers still choose Unlikely or Very Unlikely.

5.6 Group behaviour

In the survey, 67.3% of passengers were either Likely or Very Likely chose the QF1 (Find companion to escape together) strategy. As shown in Table 12, the multinomial logistic regression analysis shows that the correlation coefficients between the experience on board and the number of people travelling together are positive, but the statistical characteristics were not significant. When compared to the condition of Very Unlikely, under the premise of Likely, the education level is significant at 95% confidence level, the correlation coefficient is -0.384 (*p=0.047*). This indicates that the education level displays statistically significant negative relevance towards the QF1 strategy, and the OR is 0.681.

Table 12

Result of multinomial logistic regression on likely behaviour QF1

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	-0.015	0.109	0.887	0.985
	3	-0.071	0.104	0.491	0.931
	4	0.075	0.1	0.451	1.078
	5	0.035	0.103	0.734	1.036
Gender (Women vs man)	2	-0.137	0.373	0.713	0.872
	3	-0.05	0.355	0.887	0.951
	4	-0.103	0.341	0.763	0.902
	5	-0.183	0.353	0.604	0.833
Education level	2	-0.151	0.212	0.475	0.859
	3	-0.362	0.202	0.074	0.696
	4	-0.384	0.193	0.047	0.681
	5	-0.085	0.199	0.667	0.918
Mobility	2	-0.145	0.176	0.411	0.865
	3	-0.054	0.166	0.744	0.947
	4	0.276	0.16	0.086	1.317
	5	0	0.166	0.999	1
Experience on board	2	0.205	0.291	0.481	1.228
	3	0.147	0.275	0.592	1.159
	4	0.048	0.263	0.854	1.05
	5	0.067	0.273	0.805	1.07
The number of people travelling together	2	0.321	0.224	0.152	1.378
	3	0.303	0.213	0.154	1.354
	4	0.214	0.204	0.294	1.238
	5	0.176	0.21	0.404	1.192
Evacuation education or training experience	2	-0.278	0.197	0.157	0.757
	3	-0.428	0.187	0.022	0.652
	4	-0.249	0.179	0.164	0.78
	5	-0.001	0.185	0.996	0.999

Note: The reference category is 1 (Very Unlikely).

Group behaviour is a common phenomenon in the process of evacuation, and has attracted the attention of many researchers (Casareale et al., 2017; Kvamme, 2017; Hurley, 2016; Kim et al., 2004; Lee et al., 2003; Proulx et al., 1995; Sime, 1983). As reported in Casareale et al. (2017), in the evacuation of passenger ships, 53% of the personnel would find familiar personnel after hearing an evacuation alarm. Similarly, this study also supported the phenomenon of group behaviour. One of the main reasons for the formation of evacuation groups is the mutual help and support of people in the group, and the consultation of evacuation strategies to improve the sense of security (Ahola et al., 2014; Mawson, 2007). However, evacuation managers should be concerned about the dangers of group behaviour. On one hand, the formation of groups wastes time, leading to delays in evacuation; on the other hand, someone who helps a small number of people may miss the best evacuation opportunity, thus leading to the collective exposure to more dangerous situations, and deaths (Haghani and Sarvi, 2019c; Kvamme, 2017; Hurley, 2016).

5.7 Impatient behaviour

In the survey, 63.4% of passengers said that they either Likely or Very Likely to be impatient. As shown in Table 13, the multinomial logistic regression model shows that the correlation coefficients of age group, gender, and education are negative, and at the 95% confidence level, the educational level is statistically significant. When compared to the condition of Very Unlikely, under the condition of Very Likely, the correlation coefficient of education level is -0.443 ($p=0.043$). This indicates that the education level will have statistically significant positive correlation with the QG1 (Impatience) strategy, and the OR is 0.642.

Table 13

Result of multinomial logistic regression on likely behaviour QG1

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	-0.038	0.119	0.751	0.963
	3	-0.164	0.116	0.160	0.849

	4	-0.046	0.113	0.688	0.956
	5	-0.026	0.115	0.825	0.975
Gender (Women vs man)	2	-0.566	0.406	0.164	0.568
	3	-0.352	0.397	0.375	0.703
	4	-0.538	0.387	0.164	0.584
	5	-0.623	0.394	0.114	0.536
Education level	2	-0.697	0.228	0.002	0.498
	3	-0.629	0.221	0.004	0.533
	4	-0.701	0.215	0.001	0.496
	5	-0.443	0.219	0.043	0.642
Mobility	2	-0.417	0.199	0.036	0.659
	3	-0.323	0.194	0.095	0.724
	4	0.02	0.189	0.917	1.02
	5	-0.276	0.193	0.152	0.759
Experience on board	2	0.123	0.311	0.692	1.131
	3	-0.199	0.303	0.512	0.82
	4	-0.248	0.294	0.399	0.78
	5	-0.172	0.301	0.568	0.842
The number of people travelling together	2	-0.077	0.233	0.740	0.926
	3	0.01	0.227	0.965	1.01
	4	-0.132	0.22	0.548	0.876
	5	-0.057	0.225	0.801	0.945
Evacuation education or training experience	2	-0.032	0.212	0.879	0.968
	3	0.017	0.206	0.934	1.017
	4	0.192	0.2	0.338	1.211
	5	0.278	0.204	0.173	1.32

Note: The reference category is 1 (Very Unlikely).

Evacuation analysis would be out of touch with reality and not instructive if it did not take into account factors such as passengers' impatience, and irrational or impulsive behaviour that is caused by the complex environment of the ship (Lee et al., 2003). In the "Costa Concordia" accident, passengers did not understand the evacuation procedures in the event of an emergency after the ship left the port. When the unsafe situation was observed, some passengers chose to go to the lifeboat, not listening to the crew. However, in the "Sally Albatross" accident, the accident occurred during the day, and the passengers understood the actual situation of the accident, coupled with the effective guidance of the crew. The crowd did not become out of control or follow irrational crowding, and there were no subsequent casualties (Nevalainen, 2015). This survey did not find differences between impatient behaviour, and gender and age groups. However, the results show that the education level has a statistically significant impact on impatient behaviour. The higher the level of education, the less likely passengers are to exhibit impatient behaviour.

Due to the existence of impatient behaviour, the degree of urgency will lead to unreasonable decision-making by the evacuation personnel and affect their behaviour. In view of this, the ship manager should conduct training on the management of the crowd for the staff

to understand the passenger's habit characteristics in advance. It is desirable to communicate with passengers in an emergency in time to improve the safety of crowd management.

5.8 Carrying luggage

Similar to QD1, people choosing to carry luggage during the evacuation process could be keen in picking up their valuable belongings. According to Table 2, 40.8% of passengers indicated that they were either Likely or Very Likely chose the QH1 (Carry luggage during and escape) strategy. As shown in Table 14, the multinomial logistic regression analysis shows that the correlation coefficients between gender, the number of people going along, and experience of evacuation education are positive. When compared to the condition of Very Unlikely, under the condition of Very Likely, the correlation coefficient of the age group is -0.206 (*p=0.004*), which means that the age group has a statistically significant negative impact on the QH1 strategy, and the OR is 0.814. The correlation coefficient of the experience on board is -0.415 (*p=0.023*), which shows that the experience on board has statistically significant negative interactive effects on the QH1 strategy, and the OR is 0.66.

Table 14

Result of multinomial logistic regression on likely behaviour QH1

Demographics	Likeli-hood	B	SE	P	OR
Age group	2	-0.082	0.068	0.226	0.921
	3	-0.126	0.067	0.060	0.882
	4	-0.206	0.068	0.002	0.814
	5	-0.206	0.072	0.004	0.814
Gender (Women vs man)	2	0.223	0.209	0.286	1.25
	3	0.205	0.207	0.324	1.227
	4	0.336	0.21	0.110	1.4
	5	0.094	0.226	0.677	1.099
Education level	2	-0.289	0.13	0.027	0.749
	3	-0.265	0.128	0.039	0.767
	4	-0.075	0.128	0.557	0.927
	5	0.174	0.136	0.202	1.19
Mobility	2	-0.342	0.114	0.003	0.71
	3	-0.44	0.112	<0.001	0.644
	4	-0.451	0.112	<0.001	0.637
	5	-0.603	0.12	<0.001	0.547
Experience on board	2	-0.184	0.167	0.271	0.832
	3	-0.52	0.167	0.002	0.595
	4	-0.563	0.167	0.001	0.57
	5	-0.415	0.182	0.023	0.66
The number of people travelling together	2	0.169	0.125	0.177	1.185
	3	0.317	0.126	0.012	1.373
	4	0.204	0.127	0.108	1.226
	5	0.279	0.136	0.041	1.322
Evacuation education or training experience	2	0	0.119	1.000	1
	3	0.058	0.118	0.622	1.06
	4	0.17	0.118	0.151	1.185
	5	0.342	0.126	0.006	1.408

Note: The reference category is 1 (Very Unlikely).

Currently, there is little research regarding luggage carried by personnel during the evacuation process. Among the few research results, the proportion of passengers carrying luggage in the evacuation of high-speed railway personnel is 69.16%, of which 5.03% of passengers will choose to carry all of their luggage (Chen et al., 2014). The proportion of men carrying luggage in evacuation of bus station personnel is 50.9%, and that of women is 32.3% (Zhang et al., 2017). In high-rise buildings, only 26.5% of people adopt a completely risk-averse strategy and choose not to collect personal items, while 18.1% of people choose to take the highest risk, that is, collect all personal items (Bode and Codling, 2019). The results of this study show that during the evacuation of passenger ships, a certain percentage of passengers still chose to carry their luggage. The younger the passengers and the less experience on board, the more likely they are to carry the luggage during the evacuation process. In the actual evacuation process, the evacuation of personnel carrying luggage will not only affect the evacuation speed of pedestrians but also affect the floor space of personnel during the journey, occupying large evacuation space and reducing traffic efficiency. During the emergency evacuation process, the evacuated person may carry the luggage to the vicinity of the exit, and temporarily decide to abandon the luggage to escape due to the situation. At this point, the luggage evolves into a non-fixed obstacle that hinders the evacuation, affecting the overall evacuation process.

5.9 Temporary leadership behaviour

In the survey, 56.7% of passengers Likely or Very Likely chose the QI1 (Follow the temporary leader) strategy. As shown in Table 15, the multinomial logistic regression analysis shows that the correlation coefficients of mobility are positive, but the statistics were not significant.

Table 15

Result of multinomial logistic regression on likely behaviour QI1

Demographics	Likeli-hood	B	SE	P	OR

Age group	2	0.013	0.099	0.894	1.013
	3	0.061	0.094	0.514	1.063
	4	0.011	0.093	0.908	1.011
	5	-0.092	0.095	0.335	0.912
Gender (Women vs man)	2	-0.183	0.358	0.608	0.832
	3	-0.523	0.34	0.123	0.592
	4	-0.445	0.336	0.185	0.641
	5	-0.582	0.344	0.091	0.559
Education level	2	-0.311	0.194	0.109	0.732
	3	-0.405	0.185	0.028	0.667
	4	-0.287	0.181	0.114	0.751
	5	0.033	0.186	0.859	1.034
Mobility	2	0.206	0.166	0.215	1.229
	3	0.309	0.158	0.051	1.362
	4	0.494	0.157	0.002	1.638
	5	0.226	0.161	0.159	1.254
Experience on board	2	-0.112	0.273	0.681	0.894
	3	-0.193	0.261	0.460	0.825
	4	-0.388	0.257	0.132	0.678
	5	-0.316	0.265	0.233	0.729
The number of people travelling together	2	-0.045	0.203	0.826	0.956
	3	0.087	0.194	0.655	1.09
	4	0.115	0.191	0.547	1.122
	5	0.144	0.197	0.465	1.155
Evacuation education or training experience	2	-0.086	0.18	0.634	0.918
	3	-0.179	0.171	0.295	0.836
	4	-0.181	0.169	0.283	0.834
	5	0.2	0.173	0.249	1.221

Note: The reference category is 1 (Very Unlikely).

In an urgent situation, some people choose to rely or focus on leaders due to their fear of danger. Existing research literature shows that one of the factors that causes impatience or irrational behaviour is the lack of leaders, or the lack of highly convincing leaders. Similarly, the location of people with strong leadership will also have an impact on evacuation (Hurley, 2016; Nevalainen, 2015; Lee et al., 2003). Although this survey does not find a significant impact of demographic characteristics on the QI1 strategy, it is found that a certain percentage of passengers chose the QI1 strategy during the evacuation process. In view of this, ship managers or fire engineers should fully understand the impact of leadership behaviour on evacuation and recognize that people with potential leadership qualities are more likely to respond positively and assume leadership roles. These people should then be organised to undertake specialist fire safety training to ensure that they provide accurate information and take appropriate action during evacuation (Hurley, 2016; Fridolf et al., 2013).

6. Conclusion

The complex structure, narrow spaces, the high density of personnel, and the unfamiliarity of the passengers with the ship's environment make the passenger ship evacuation significantly

838 different land-based evacuation. However, due to the associated high cost and difficulty to
839 conduct experimental research or investigation, previous research has focused on theoretical
840 evacuations and simulation. There are limited studies on the likely behaviour of passengers
841 during ship evacuations, and reliable empirical data is not sufficiently available.

842 To understand the passengers' likely behaviour and demographic differences in the
843 evacuation process of passenger ships, based on the existing literature, a survey of the likely
844 behaviour of passengers was conducted on a Ro-Ro passenger ship between the Shandong
845 Peninsula and the Liaodong Peninsula. The results of the study show that in pre-evacuation,
846 passengers are more likely to take the initiative to respond to evacuation alarm and observe
847 others' actions. Regarding path-finding behaviour, passengers are more likely to choose to
848 follow the evacuation instructions or guidance. In the counter flow behaviour, when a
849 passengers family is left behind, elderly passengers travelling with a group of people are more
850 likely to choose to return. Passengers are more likely to have cooperative behaviour than
851 competitive behaviour, and elderly passengers travelling with a group of people are more likely
852 to choose to help others. Among other behaviours, highly educated passengers are less likely
853 to have group and impatient behaviour. Passengers who experienced more trips on board are
854 less likely to carry luggage during an evacuation, while the demographic characteristics of
855 temporary leadership behaviour are not statistically significant.

856 The results of this study are important for understanding the behaviour of passenger ship
857 evacuation, and for developing and verifying evacuation models. Simultaneously, the results
858 of this survey will help passenger ship managers to develop appropriate management strategies
859 and conduct effective evacuation education activities. For example, our research results show
860 that passengers are highly dependent on staff during path-finding and when the exits are
861 congested. Therefore, ship managers should organize appropriate evacuation training to clarify
862 the role and responsibilities of staff in emergency situations, make an emergency response plan

to better manage crowding and improve the safety level of Ro-Ro passenger ships.

This study could be a systematic result of the likely behaviour of passenger ship evacuation. In interpreting the findings, the following methodological discussions are given:

(1) The questionnaire research has a series of limitations. The "closed question" adopted in this study in which the answers listed inevitably restricted the respondents, may also lead to the limitation of the respondents' thinking. For example, a certain evacuation behaviour of passengers may be affected by a combination of factors and may be affected by additional factors not listed. More importantly, not all respondents have experienced the questions listed in the questionnaire. Consequently, participants had to try to predict how they would behave in an evacuation which may lead to inconsistencies with the actual situation.

(2) Compared with Ahola and Mugge (2017)'s research on passenger ship safety experience, this research conducted questionnaire surveys in a real ship environment. However, it is possible that not all participants fully understood the questions in the questionnaire. Participants needed to be given explanations, and then their potential reaction behaviours were estimated. Investigation of such behavioural intentions may make it difficult for participants to determine their behaviour. To this end, it is proposed to use virtual reality technology to study the evacuation behaviour on passenger ships in the future, allowing passengers to move in different areas within the ship, see multiple perspectives, and then investigate the actual evacuation behaviour.

(3) In this study, only limited information was collected on passenger demographics and choices on a Ro-Ro passenger ship traveling between Liaodong Peninsula and Shandong Peninsula for 45 days. Although 1,380 survey results were utilised, the time span of the survey may not be long enough. In addition, passengers of different regions and cultural backgrounds may react differently due to cultural differences and the impact of social issues. For this reason, it is proposed to extend the survey time span in the future and investigate the emergency

evacuation behaviour of Ro-Ro passenger ships in other regions, as well as conduct a comparative analysis.

(4) This study analysed the likely emergency evacuation behaviour of passengers on a Ro-Ro passenger ship, however, it may be worth investigating certain behaviours more comprehensively. For example, when passengers choose an exit during evacuation, it is necessary to know if they consider a single criterion or if there is a combination of factors for consideration. If it is the latter, then it is useful to investigate the contributing factors, along with any significant differences between them, and their influence in decision-making.

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Appendix A. Questionnaire of the survey

Category	Content	The specific options
Basic information	Gender	☐Male; ☐Female
	Age group	☐16 and below; ☐16～25; ☐26～30; ☐31～40; ☐41～50; ☐51～60; ☐61 and above
	Education level	☐Primary and below; ☐Secondary school; ☐College; ☐Graduate students and above
	Mobility level	☐Very poor; ☐Poor; ☐Neutral; ☐Good; ☐Very good
	Experience on board	☐Never; ☐1; ☐2-4; ☐5 or more
	Number of people travelling together	☐Alone; ☐1; ☐2-5; ☐6-10; ☐11 or more
	Ship evacuation education/ training experience	☐Never; ☐Have, but do not remember; ☐Once a year; ☐More than once a year

Category	Question NO.	Variables	Very Unlikely	Unlikely	Neutral	Likely	Very Likely
Emergency evacuation behaviour	***QA***	***Pre-evacuation behaviour***					
	QA1	Waiting for staff confirmation	1	2	3	4	5
	QA2	Escape immediately	1	2	3	4	5
	QA3	Observe others' movements	1	2	3	4	5
	QA4	Proactive confirmation	1	2	3	4	5
	QB	***Path-finding behaviour***					
	QB1	Choose the nearest exit	1	2	3	4	5
	QB2	Choose the most familiar exit	1	2	3	4	5
	QB3	Follow the majority	1	2	3	4	5

QB4	Follow the evacuation guide or PA	1	2	3	4	5
QC	***Behaviour during exit congestion***					
QC1	Queuing patiently	1	2	3	4	5
QC2	Self-Finding other exits	1	2	3	4	5
QC3	Squeezing forward	1	2	3	4	5
QC4	Obeying the crew	1	2	3	4	5
QD	***Counter flow behaviour***					
QD1	Return when valuables left behind	1	2	3	4	5
QD2	Return when family left behind	1	2	3	4	5
QE	***Competition and cooperation behaviour***					
QE1	Help others	1	2	3	4	5
QE2	Push others	1	2	3	4	5
QF	***Group behaviour***					
QF1	Find companion to escape together	1	2	3	4	5
QG	***Impatient behaviour***					
QG1	Impatience	1	2	3	4	5
QH	***Carrying luggage***					
QH1	Carry luggage during escape	1	2	3	4	5
QI	***Temporary leadership behaviour***					
QI1	Follow the temporary leader	1	2	3	4	5

Appendix B. The results of Wilcoxon single-sample test of each likely behaviour and the results of Wilcoxon signed-rank test of QD and QE

Table B1 The results of Wilcoxon single-sample test of each likely behaviour

Question NO.	Variables	Test statistic	Standardized test statistic	Standard error	Significance
QA	***Pre-evacuation behaviour***				
QA1	Waiting for staff confirmation	353,402.5	8.521	9,403.930	P < 0.001
QA2	Escape immediately	341,308.5	10.331	8,716.922	P < 0.001
QA3	Observe others' movements	422,845.5	14.568	9,542.949	P < 0.001
QA4	Proactive confirmation	477,672.0	17.227	10,088.691	P < 0.001
QB	***Path-finding behaviour***				
QB1	Choose the nearest exit	468,781.0	18.021	9,817.019	P < 0.001
QB2	Choose the most familiar exit	497,894.0	20.438	9,921.218	P < 0.001
QB3	Follow the majority	509,535.0	21.107	10,003.393	P < 0.001
QB4	Follow the evacuation guide or PA	576,285.5	21.974	10,982.490	P < 0.001
QC	***Behaviour during exit congestion***				
QC1	Queuing patiently	493,170.0	19.159	10,052.259	P < 0.001
QC2	Self-Finding other exits	390,343.5	16.642	8,597.984	P < 0.001
QC3	Squeezing forward	327,638.5	4.072	9,709.524	P < 0.001
QC4	Obeying the crew	504,432.5	20.849	9,961.164	P < 0.001
QD	***Counter flow behaviour***				
QD1	Return when valuables left behind	435,939.5	16.204	9,617.194	P < 0.001
QD2	Return when family left behind	531,335.0	21.150	10,413.588	P < 0.001
QE	***Competition and cooperation behaviour***				
QE1	Help others	431,094.0	17.917	9,127.787	P < 0.001
QE2	Push others	339,733.0	6.197	9,537.074	P < 0.001
QF	***Group behaviour***				
QF1	Find companion to escape together	520,780.0	21.121	10,112.688	P < 0.001
QG	***Impatient behaviour***				
QG1	Impatience	499,583.5	19.799	10,023.718	P < 0.001
QH	***Carrying luggage***				
QH1	Carry luggage during escape	300,924.0	4.492	9,032.354	P < 0.001
QI	***Temporary leadership behaviour***				
QI1	Follow the temporary leader	410,068.0	17.309	8,884.522	P < 0.001

Table B2 The results of Wilcoxon signed-rank test of QD and QE

Group	Z	Sig.
QD1-QD2	-7.244	P < 0.001
QE1-QE2	-10.858	P < 0.001

Appendix C. Supplementary material

Supplementary data associated with this research can be found, in the online version, at

913 https://data.mendeley.com/datasets/nbb3wc92x7/draft?a=25941f4b-9740-4e82-ae49-
914 086dbbab044c

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