Heliyon 9 (2023) e16958

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

The application of the Haddon matrix in identifying drowning prevention solutions in the north of Iran

Ali Davoudi-Kiakalayeh [a], Jalal Barshan [a], Faezeh Emami Sigaroudi [a], Hamed Mousavi Mirak [a], Seyed Ahmad Naseri Alavi [b,*]

[a] Guilan Road Trauma Research Center, Guilan University of Medical Sciences, Rasht, Iran
[b] Tabriz University of Medical Sciences, Tabriz, Iran

ARTICLE INFO

Keywords:
Prevention
Drowning
Haddon matrix
Guilan
Iran

ABSTRACT

The application of the Haddon matrix in identifying drowning prevention solutions in the north of Iran is necessary. We dealt with drownings on three levels of prevention including before, during, and after the injury in northern Iran (Guilan province). This study aimed to investigate the use of Haddon's matrix in preventing three-level drowning cases before, during, and after the accident in the north of Iran. This qualitative study consisted of 9 focus groups with a sample size of 78 people including 48 nursing staff, 21 emergency medicine specialists, and 30 people from non-medical personnel (local community leaders, executive officials of relevant organizations, lifeguards, staff working in health centers, and families of victims). All group discussions were recorded and the questions were based on the focus group table. According to Haddon's table of results, the major risk group was the young and adolescent boys and more in the area of neglect in culture-building and education. In this study, the role of factors was investigated separately and the necessary solutions were presented that can be used as a scientific and practical basis to achieve the main goal of drowning prevention. These strategies require cross-sectoral collaboration, which seems to be a strong interaction with a greater focus on major risk groups to address deficiencies and prevent the recurrence of potential accidents. The study aimed to investigate the use of Haddon's matrix in the prevention of three-level drowning cases before the event, during the event, and after the event in northern Iran.

1. Introduction

Among the accidents, falling into the water and being submerged in it is one of the most common and at the same time preventable causes of injury and death in people. A recent new consensus was made to define drowning as the process of experiencing respiratory impairment from submersion or immersion in liquid [1,2]. The latest results from the World Health Organization (WHO) show reported that 236,000 people died from drowning in 2019. Also, in the same year, drowning was the third leading cause of unintentional injuries internationally, accounting for 8% of all mortality and 7% of all deaths from injuries and injuries [3]. In people between 1 and 24 years, drowning is among the ten-leading cause of death. More than 90% of drowning deaths occur in low- and middle-income areas especially in Africa [4]. Over time, the mean age-related drowning death decreased and it is shown that about half of unintentional

* Corresponding author.
E-mail addresses: davoudikiakalayeh@gmail.com (A. Davoudi-Kiakalayeh), jalalbarshan13@gmail.com (J. Barshan), faeze.emami2050@gmail.com (F. Emami Sigaroudi), mirhamed2022@gmail.com (H.M. Mirak), dr.arsalan2010@gmail.com (S.A. Naseri Alavi).

https://doi.org/10.1016/j.heliyon.2023.e16958
Received 26 October 2022; Received in revised form 5 May 2023; Accepted 11 May 2023
Available online 3 June 2023

Table 1
The table shows the Haddon matrix.

Time	Host	Agent	Physical Environment	Sociocultural Environment
Pre-event	Is the person at risk?	Is the carrier dangerous?	Is the environment dangerous? Does the environment have characteristics to reduce or increase risks?	Does the environment strengthen or weaken existing risks?
Event	Is the person able to resist the transmitted energy or force?	Does the carrier provide protection?	Has the environment been effective in treating trauma after the accident?	Has the environment been effective in treating trauma after the accident?
Post-event	What is the severity of the injuries and damages?	Is the carrier effective in causing damage?	Has the environment caused additional damage after the accident?	Has the environment been effective in recovery?

death occurred in China, India, Pakistan, and Bangladesh in 2017 [5,6].

People drown at any age, but two age groups drown more often. The first age group is preschool children. They can drown in less than 3 cm of water and are the second age group of teenagers. The highest rate of death due to drowning incidents is in the age group below 20 years and more in children 0–4 years old. Drowning is responsible for 90% of fatal injuries in children aged 1–4 and 50% of fatal injuries in children aged 5–9. Studies have shown that drowning is the second limiting factor of useful life years after accidents and traffic accidents. Survivors may suffer severe and permanent respiratory disorders and psychological complications that can cause life conditions in these people. Also, after being saved from drowning, this event may have many psychological effects on the family of the victims [7–9].

Drowning occurs during various daily or recreational activities of people such as swimming, boating, fishing, etc. [10]. People living in different areas may be exposed to different sources of water such as the sea, lake, river, dam, pool, etc. [11]. Predisposing factors, such as some high-risk behaviors, including drinking alcohol and not using rescue equipment, are also different in different regions of the world under the influence of different cultural issues [12].

More than half of deaths from drowning worldwide statistics are related to people under 25 years old. Also, the number of discovered male victims is double that of female victims. More than 90% of the victims are from the income and middle class, and the highest statistics are related to Africa, Southeast Asia, and the Western Pacific [13].

Haddon's Matrix was presented by Dr. William Haddon for a better understanding and analysis of any desired event in the seventies, and it is a combination of the epidemiology triangle including man, environment, and agent in the environment with three dimensions of the event including before and after. Haddon's matrix is a dynamic model that examines causality and provides the possibility of intervention in pre-accident, during-accident, and post-accident stages. This matrix can be used not only for the management of traffic injuries, but also for the management of burns, drowning, falls, and other incidents, and in fact, it is the first systemic approach to incidents such as traffic injuries.

We can use the event instead of the incident because the incident carries an unpredictable and unpreventable negative charge. Whereas the events are manageable. Haddon matrix is a definition for a better understanding of traffic damage and other desired events. From the factor and time, a matrix is formed in the following form, which is completely dynamic [14,15].

Haddon's matrix has been used as a model for managing victims of all kinds of injuries and accidents. This matrix is a grid arranged as a table with four columns and three rows. The four columns are related to the host, carrier, physical condition, and environmental conditions, the three rows of this table (Table 1) are assigned to the three time periods before, during, and after the damage event [16–21].

There are very few studies on the use of the Haddon matrix in drowning, hence, this study aimed to investigate the use of Haddon's matrix in the prevention of three-level drowning cases before the accident, during the accident, and after the accident in the north of Iran.

2. Materials and methods

The present study used the Haddon matrix to identify solutions for drowning prevention in water in Gilan province. In this study, data were drawn from nine Focus group discussions (FGD). Each group included 8–10 members. The sample size was 78 people including 48 people from medical personnel (nursing staff, emergency medical personnel, medical and emergency training staff) and 30 people from non-medical personnel (local community leaders, executive officials of relevant organizations, lifeguards, staff working in health centers and families of victims).

Experts and medical staff were asked about their experience qualitatively (Table 2). Participants were selected from nurses and physicians of the emergency department and trauma and parents of the children confronted with drowning in the past. The questions were specific for each group of participants and were not the same. There was one leader which was the first author of the paper for all groups and asked specific questions of participants. Sampling was purposeful and the selected sample was done according to the principle of diversity. Therefore, the participants were selected from different ages, gender, educational, occupational, and social groups to hear different opinions and find a more comprehensive in this field. Sampling continued until information saturation, that is, the absence of classes, subclasses, and new information. The interviews were conducted in person and in the field.

Based on the Haddon matrix and the relationship between the three states before the event, during, and after the event with existing changes, qualitative analysis was done. All the factors considered by the participants were identified and classified. Informed consent was obtained from all the patients before the study enrollment.

After the approval of the plan by the Ethics Committee of the Guilan University of Medical Sciences with the code of ethics IR.

Table 2
The table shows the focus group questions asked from nurses and physicians.

Nurses' focus group questions	Physicians' focus group questions
1- Express your feelings and views about drowning.	1- Where do you think people drown the most? If there is a sea, where is the sea? If it is in freshwater, where does it happen more?
2- Where do you think most people drown? If there is a sea, where is the sea? If it is in freshwater, where does it happen more?	2- In what age group do drownings usually occur? Is it more in boys or girls?
3- In what age group do drownings usually occur? Is it more in boys or girls?	3- What do you think is the cause of drowning in the sea? What is the cause of drowning if it happens in freshwater?
4- What do you think is the cause of drowning in the sea? What is the cause of drowning if it happens in freshwater?	4- What time of the day is it most common?
5- What time of the day is it most common?	5- What should be done at sea to prevent drowning? For adults? and children
6- What should be done at sea to prevent drowning? For adults? And children?	6- To prevent drowning in freshwater such as rivers, pools, dams, canals, etc., what should we do for adults? And for children?
7- To prevent drowning in freshwaters such as rivers, pools, dams, canals, etc., what should we do for adults? And for children?	7- What organization do you think is responsible for rescue and rehabilitation on the coast?
8- What measures should we take to prevent drowning at the level of individuals or families?	8- Is resuscitation of drowned people the same as resuscitation of patients in the hospital?
	9- What do you suggest to save more people from drowning accidents? In the sea as well as fresh waters such as rivers, dams, canals

GUMS.REC.1401.076, the meetings of the groups started. In all group meetings, the researchers participated as coordinators and the management of the meetings was by the participants. All group discussions were recorded and the questions were based on the table of the focus groups. The records recorded in the focus groups for three stages before the accident, during the accident, and after the accident was collected and implemented.

At first, focus group discussion was used to select the groups to be studied, and then the snowball method was used to select the people present in each group. Nine groups were considered to form FGD. The people present in each of the subgroups were selected based on the snowball method, and meetings were held in the form of focus groups of at least 8 people for each of the 9 focus groups, and. In these group discussions, we evaluated the three stages before the accident, during the accident, and after the accident. The method of determining focus groups was determined based on the level of their duties in the three mentioned levels and using the FGD (Table 3).

During this qualitative research, 7 discussion groups (focused group discussion) were formed with the studied groups. There were 27 participants in the focus group of nurses of Porsina Hospital of Guilan University of Medical Sciences and 21 participants in the focus group of medical staff and emergency specialists of the Hospital. Other focus groups and mostly party groups with the executive organizations of related organizations, lifeguards, emergency staff and red crescent, health education and diseases working in health centers and victims' families, 6 people from each group. The invitation was made separately and the necessary topics were discussed according to the predetermined topics and questions. The opinions of the attendees were recorded with their knowledge and confidentially, and after implementing the opinions using the Haddon matrix tool from the interview and group discussion guide and the analytical tool of this study; First, based on the application phase, they were classified into three stages before the accident, during the accident, and after the accident, and then in each stage, based on the place of influence and function of the opinions, based on the opinion about which of the Haddon triangle cases, they play a role. Whether they play a role in the human factor or the environmental factor (socio-economic or time-related) or the vector factor were included in another category and we obtained the Hedonic table given below. At each stage, based on the discussions and conclusions made in the main risk groups, there are major risk groups based on the internal summaries that can be included in the risks in the field of preventing drowning or minimizing the damage (Table 4).

2.1. Credibility

In the present study, the review of the participants was used to ensure the accuracy of the data. In addition to this method, supervisor review was another method that was used to confirm the validity of the data. For this purpose, the text of the interviews was extracted based on codes. The classes were provided for skilled experts in qualitative research methods. Then, they were requested to check the correctness of the coding process.

2.2. Verification capability

One of the audit techniques for developing confirmation in qualitative studies was the step-by-step report of the research process from the beginning to the end of the protocol, which helps to clarify the details of the research process fully. The researchers in the present study tried to record all the stages of the research so that other researchers could follow the data. Recording the statements of the participants, writing down the statements, and reviewing them by the participants and expert supervisors were among the activities that helped to provide the criteria for confirming the findings of the research.

Table 3
The table shows the focus groups investigated in the present study.

group	Pre-event	Event	Post-event
Lifeguard Rescue	- What are the ways to secure the water environment to prevent accidents? - What are the ways to increase a person's safety in water sports? - What are the approaches to improve notification and necessary warnings when necessary?	What is the way to help quick action in rescue and rescue in increasing success?	What are the strategies that help in the quick transfer of the injured?
Emergency and Red Crescent staff	- What are the solutions to minimize the time wasted in rehearsals? - What are the existing suggestions and methods to increase public education?	What are the necessary solutions to increase success in resuscitation and rescue in the event of an accident?	- What are the ways to reduce the time of transferring the injured to the medical center? - What are the ways to increase the quality of resuscitation measures during the transition?
Porsina Hospital emergency nursing staff	- What is the level of preparation of the nursing staff in dealing with the drowning person and the ways to increase the quality of their training and necessary preparations?		- How is it possible to reduce the time required to enter the patient? - What are the suggested ways to increase the quality and success rate of rehabilitation? - What are the ways to improve care and support for the patient after recovery? - What is the level of preparation of the nursing staff in dealing with the drowning person and the ways to increase the quality of their training and necessary preparations?
Poursina Hospital emergency medicine specialist medical staff	- What are the suggested methods to increase public education? - What are the ways to increase the training of relief and nursing staff? - What are the suggested ways to increase the safety of water environments? - What are the ways to increase preparation and training and use of the latest resuscitation methods and necessary equipment among the medical staff?	What are the helpful methods to improve the quality of resuscitation of the injured during the accident and reduce the subsequent injuries?	- What are the necessary recommendations to improve the necessary support for the patient upon arrival? - In your opinion, which cases are more important in reviving a drowning patient than other cases that may be neglected? - What do you think about improving patient support measures after resuscitation?
Officials of related organizations	- Have the necessary measures been taken to secure and determine safe water environments? - Has the cause of the previous deaths been identified and resolved? - How is the quality and quantity of social media education? - Have the methods of increasing the speed of notification in case of danger and crisis been used? - How is the proximity of relief and treatment bases to water environments prone to danger?	- has it been done properly (Equipping a sufficient number of lifeguards)? - Are there enough facilities for lifeguards in case of an accident?	**What were the measures taken to reduce the time for the patient to reach the treatment center?**
Health and disease education experts	What measures do you suggest to expand drowning prevention training and first aid measures at the community level and among related people? What are the practical and effective ways to develop the education of children and parents in school?	What do you suggest about the development of a scientific and principled approach to a drowning person?	**What measures do you consider useful regarding the accurate recording of drowning statistics and information?**

(*continued on next page*)

Table 3 (*continued*)

group	Pre-event	Event	Post-event
	What suggestions do you have about how to increase the safety principles of aquatic environments and the necessary equipment? What solutions do you suggest for quick rescue operations and information in critical situations? What measures do you consider to be practical and effective in terms of holding educational and briefing sessions at the level of relevant authorities and councils and village councils? Do you have an opinion on the development of the use of mobile phones for the location of accident victims?		
The family of the victims		What things do you consider to be involved in the occurrence of the accident? What deficiencies do you consider important and what are your recommendations to solve the problems?	What deficiencies did you face in the process of transferring and treating the injured and what are your recommendations to solve the problems?

2.3. Transferability

The researchers in the present study checked the transferability of their study by providing the findings of this research to some readers and getting their approval. Covering a wide range of participants in terms of age, gender, education, marriage, etc. was another effort to provide the transferability of the findings for evaluation and judgment by others. On the other hand, the researchers provided the possibility of transferring it to the researchers in similar environments with a detailed description of the background of the participants in this study.

2.4. Ethics approval number

IR.GUMS.REC.1401.076

3. Results

3.1. FGD results with different groups

View on drowning

- The most common feeling when dealing with a drowning person is related to a “feeling of death and suffocation”, followed by “fear” and “complete confusion".
- All groups believed that drowning is a health problem, but not enough attention is given by the relevant authorities.

Who drowns and why?

- Most of them stated that the probability of death or morbidity due to drowning is much higher in men than in women. In general, the rate of drowning in men is more than twice that of women, and the reason is that compared to women, men are at a higher risk due to more exposure to water and more risky behaviors (such as swimming alone or after alcohol use). They are destined to drown.
- The largest drowning group is “young boys and teenagers aged 20 to 30". The main reason for this issue was “false self-confidence".
- The occupational death rate is higher among fishermen, especially in the winter season when the beaches are not covered by relief organizations.

Where do drownings occur?

- Most drowning places have been considered “freshwater”, which mainly included rivers, pools, or canals.

Table 4
Investigating effective factors in preventing drowning based on the Haddon matrix.

	Host	Agent	Physical Environment	Sociocultural Environment
Pre-event	Sea: The highest risk group: men (mainly young boys and teenagers) Women are at risk More than two times Cause: due to more exposure to water and more risky behaviors (such as swimming alone and under the influence of alcohol) Prevention: protecting people at risk - Swimming in places where lifeguards are present - Having swimming skills or having a partner who can swim - Training lifeguards for continuous monitoring in swimming areas and strengthening the facilities of lifeguard teams - Complying with necessary recommendations by swimmers (avoiding large meals and taking sleeping pills before swimming, having protective equipment, etc.) - Increasing people's access to public swimming pools with lifeguards to learn to swim - Teaching and forcing to avoid alcohol consumption while boating or around water bodies Risk group: children Prevention: More monitoring of children's swimming to prevent drowning in children and minors - Presence of children's parents while swimming - Teaching swimming to children (and resuscitation training along with it) and expanding swimming training programs in elementary schools (because familiarity with swimming technique and its basic principles will significantly reduce drowning.) - Use of protective equipment and tube - Supervision of local authorities in providing necessary warnings to identify dangerous environments for swimming Freshwaters: (river, canal, pool, dam …) Risk group: children Prevention: parental supervision - Infants who are left alone or with another child in the bathtub are at risk of drowning.	Sea: Risk factors in the Caspian Sea: - Swimming outside of beach plans that are not covered by rescue organizations (the most important risk factor) - Lack of access to a life jacket - Existence of splitting current Prevention: securing the aquatic environment for swimming - Determining places with safe beds and permitted areas (plans to improve the sea for swimming) - Beach sanitization plan for swimming (the presence of a lifeguard is important) - The proximity of the emergency center and the medical center to the swimming areas - Unsafe area secured for swimming and lack of expert supervision - Determining the locations of the splitting current - Unification of flags and symbols related to safe beaches and educating people about their importance Freshwaters: (River, canal, pool, dam …) Prevention: the creation of obstacles and protection - Installation of drowning warning signs in dangerous places - Compliance with protective and security measures such as fences for dams, construction of protection around swimming pools, and making it compulsory - Encouraging people to use proper covers and protection on wells - Construction of dams in flood-prone areas - Protection around village fishing ponds, water catchments that are filled with rainwater, and other sources of water accumulation around houses and at the community level as much as possible.	social: - In the north of Iran, drowning is more common for travelers and in the sea in places that are not known as swimming health plans. - Increasing parents' awareness about children's need for care supervision in rural communities, especially during agricultural activities, gardening, etc. Economical: - The specific mortality rate is higher among fishermen, especially in the winter when the beaches are not covered by relief organizations. - Fishing with small boats in rural areas as a means of livelihood is the cause of many drowning deaths in these areas. - Some people probably have a higher rate of drowning due to the difference in their economic and social status and lack of use of swimming training opportunities.	social: - In the north of Iran, drowning is more common for travelers and in the sea in places that are not known as swimming health plans. - Increasing parents' awareness about children's need for care supervision in rural communities, especially during agricultural activities, gardening, etc. Economical: - The specific mortality rate is higher among fishermen, especially in the winter when the beaches are not covered by relief organizations. - Fishing with small boats in rural areas as a means of livelihood is the cause of many drowning deaths in these areas. - Some people probably have a higher rate of drowning due to the difference in their economic and social status and lack of use of swimming training opportunities.

(*continued on next page*)

Table 4 (*continued*)

	Host	Agent	Physical Environment	Sociocultural Environment
	(The care and supervision of bathing children by parents) - In rural areas, children are killed as a result of playing and mostly because of falling into canals and ponds. - Supervision by parents to use of village wells and home pools or fields - Children with epilepsy and convulsions are at a higher risk of drowning in the bathtub or swimming pool and canal compared to healthy children. - Providing public education by radio and schools in terms of safety tips and necessary recommendations (the most important action is education) - Increasing parents' awareness about children's need for supervision inside and outside the home and establishing child care mechanisms or forming teams of parents to care for children in rural communities (especially during harvest) - Teaching children to avoid entering streams and rivers with fast water flow and swimming alone - The role of local authorities in identifying dangerous places for recreation in villages and around canals	- Encouraging people to protect houses located near water sources (rural houses) Prevention: removing the risk factor - The role of the Road Construction Department in eliminating accident-prone spots and creating adequate protection and lighting at canal crossings - Emptying the unnecessary water collected in the bathtub, basin, or buckets. - Construction of safe bridges across wetlands and canals		
Event	Sea: reasons: - Willingness to take risks and experience greater depths - False confidence - Lack of swimming skills Freshwaters: reasons: - False confidence - Lack of swimming skills - Error in detecting depth - Slipping because of taking selfies - The slippery side of rivers or dams - Ignorance of parents about the situation of children's recreation - High willingness of children to take risks and curiosity (the need to inform parents and children) - Attending unknown places (for fun or adventure) - Failure to wear a life jacket while boating in the	Sea: reasons: - Swimming in unsafe seabeds (Most of the passengers, in the north of Iran, mostly in the sea in places that are not known as swimming health plans) Freshwaters: The most common place for drowning Common places: (mostly in the river and dam due to the lack of lifeguards) reasons: - The possibility of getting stuck in mud and wire or fence - Strong current of the river - Accidents and cars falling into the river or canal - Car or pedestrian falling into the agricultural pool - Floods also cause many deaths due to drowning. - Home pools, especially pools that do not have rescue sinks	When: - The most common: Most in the evenings (due to leisure time) - Night (due to less visibility of people around, tide, men drown more) - It depends on the time of doing maritime work activities (such as fishing, port work, etc.) - It may happen during school hours and mostly in the summer for students who swim for fun. - School closing hours - During bad weather and hours (the volume of water in the canals increases)	- The role of culture building and the presence of the traffic police is important in opening the road for emergency vehicles to transport the injured faster.

(*continued on next page*)

Table 4 (*continued*)

	Host	Agent	Physical Environment	Sociocultural Environment
	recreational marshes of northern Iran Prevention: keeping calm and asking for help for relief - The proximity of the emergency and Red Crescent stations to the beaches plays an important role in the event of an accident in successfully rescuing the injured - Teaching everyone the first steps and calling the emergency room and asking for help from others during an accident (maintaining the airways by lying on the side and doing chest compression) In reviving a drowning person, ABC is used, and maintaining the airways is more important	- Children's access to agricultural pools is the cause of drowning and deaths of children in rural areas Prevention: establishing order and calm in the presence of rescuers		
Post-event	The largest group: - Young boys and teenagers drowned more than others reasons: - Due to false self-confidence, ignorance, the tendency to take risks in boys, showing off - Among girls, due to social restrictions in Iran, their fear of taking risks has been less	Prevention: evaluation and elimination of defects		Prevention: evaluation and elimination of defects

- The main cause of drowning in the event of a drowning incident, both in the sea and freshwater, is "false self-confidence while not having enough skills to swim" and "curiosity for danger or adventure" and, secondly, "swimming in place" "unsafe" and evaluated the role of road traumas in fresh water drowning as important.
- Fishing with small boats in rural areas as a means of livelihood is the cause of many drowning deaths in these areas.
- Swimming outside the beaches plans that are not covered by rescue organizations is the most important cause of drowning in the Caspian Sea.

When do drownings occur?

- Most drowning times are related to the "evening and sunset" hours; however, other factors such as bad weather conditions, school closing times, and the starting hours of maritime jobs are considered potential.

Preventive measures suggested?

- In the discussion of drowning prevention both in the sea and in freshwater, most recommendations related to swim and informing parents and building culture". Then there is the recommendation to "swim in safe and marked areas in the presence of lifeguards".
- To prevent drowning at the level of families and individuals, they included the most recommendations related to "increasing the safety of wells" and "providing public education" in the next degree.
- To save more people from drowning, most participants mentioned "training on basic measures, notifying the emergency and asking for help from others" and secondly the importance of "closeness of emergency centers" to water environments. Also, the participants emphasized the importance of "maintaining the airways" in reviving a drowning person compared to reviving a non-drowning person.
- Lack of access to a life jacket for swimming on the shores of the Caspian Sea is another cause of drowning.
- Failure to wear a life jacket while boating in the recreational marshes of northern Iran is considered a risk factor for drowning in these places.
- Children whose mothers had low education were at a higher risk of drowning compared to children whose mothers had a higher level of education.
- Infants who are left alone or with another child in the bathtub are at risk of drowning.
- In rural areas, children are killed as a result of playing and mostly because of falling into canals and ponds.
- Drowning in young children is mainly related to a lack of supervision.

- Children with epilepsy and convulsions are at a higher risk of drowning in the bathtub or swimming pool and canal compared to healthy children.
- Some people probably have a higher rate of drowning due to the difference in their economic and social status and lack of use of swimming training opportunities.
- Floods also cause many deaths due to drowning.
- Home pools, especially pools that do not have lifeguards, can also be considered a cause of drowning.
- Agricultural pools are the cause of drowning and the deaths of children in rural areas. These deaths occur due to access to water catchers and irrigation canals of farms.

4. Discussion

Overall, this study used FCDs to explore the medical personnel and non-medical groups' perceptions regarding drowning events. According to the purpose of the study in this article, we discussed the methodological aspects of using the Haddon matrix in the occurrence of drowning incidents in the north of Iran. The Haddon matrix, developed by William Haddon, has been used in injury research and interventions for decades [22]. Some people may consider the Haddon matrix as a tool to analyze and analyze their injuries. However, by scrutinizing an issue in time and the opinion of the agents on it, the Haddon matrix can be used as an epidemiological tool. A user-friendly interdisciplinary thinking and planning tool can also be used to help understand, prepare for, and respond to a wide range of public health topics [20].

While research and prevention of drowning are necessary for a multi-sectoral approach, it is a central role in public health care. To prevent drowning, the first step is to identify the problem in the desired region, country, or neighborhood, how, where, what, who, and when. These questions are answered using available data, survey studies, incident monitoring systems, interviews with key experts, or archival documents related to secondary information sources such as newspapers (especially in the case of major disasters). Then based on these data, interventions are targeted.

4.1. Who drowns?

The findings of this study showed that the highest risk group is boys and teenagers, they can be the most drowned in the age group of children., several studies in Iran confirmed that the 20–30-year age are the most vulnerable [23]. In a study in the Philippines, Guevara et al. [24] examined appropriate strategies to prevent similar deaths in a selected location in the northern Philippines, which put factors at risk of drowning in accidents. Most people suffering from drowning were children and teenagers, and the things that most caused the accident included insufficient care for the child, lack of information and awareness of air strategies, and the lack of program (s) for drowning that our study was with. These findings are consistent with Sarrassat et al.'s study [21], men are at greater risk than women, while children and adolescents are at greater risk than adults. In another study [25], 82.9% were men, and the highest number of those who drowned were in the youth age group, which is consistent with our study. In our study and the study of Livy et al. [26], most drowned people were men in the youth age group. In the study of Musaibi et al. [27], 87.5% of the drowned people were boys, which was in line with our study, but all the drowning victims were children, and our findings are not consistent with this result because most of the groups were adults. Similarly, in Yang et al.'s study [28], more than half of the drowned were boys and children. In the study of Suominen et al. [29], most of the subjects were young men and then children, which our findings were like. However, the participants of nine FGDs were not aware of the teenager high-risk group and male predominance of drowning but their concept corroborated with the finding mentioned above studies.

Haddon's strategy is a useful tool for the fundamental development of interventions related to the prevention of accidents. Interventions whose effectiveness has been shown in numerous studies [19] has shown in Table 5.

4.2. Preventive measures suggested at the infrastructure level

Based on the results of these FGDs, the participants have been informed about preventive measures. These include the role of the road construction department in eliminating accident-prone areas, creating protection for dangerous places, providing sufficient lighting in canal crossings, and building safe bridges. Moreover, in the width of wetlands and canals, all boats or larger vessels should be regularly controlled in terms of safety and equipment, and should never have passengers over the allowed capacity. They could be taken into account to eliminate risk factors. In the study by Taylor et al. [9], the dangerous conditions and water environments investigated in which children may drown more often. Preliminary evidence showed that water conditions and the elimination of

Table 5
Drowning prevention approaches based on the Haddon matrix.

	Host	Environment	conveyor
Pre-event	- Protecting people at risk - Training and supervision of parents	- Securing the water environment for swimming - Creating obstacles and protection - Removal of the risk factor	- Safety monitoring - Monitoring the quantity
Event	Remain calm and ask for help for relief	Establishing order and peace for relief	Accelerate the transfer
Post-event	Limiting damage	Evaluation and elimination of defects	Evaluation and elimination of defects

accident-causing points can help reduce drowning, which is consistent with our study.

In the study of Rahman et al. [30], the importance of protecting children from environmental hazards while swimming was pointed out, and appropriate protective measures should be taken to prevent accidents, which our study is consistent with.

4.3. Preventive measures suggested at the national level

Based on the findings of this study, the respondents believed that the construction of dams in flood-prone areas, construction of protection around swimming pools and forced to comply with them, protection around village fishing ponds, water catchments filled with rainwater, and other sources of water accumulation around houses, and on the surface of the society as much as possible, encouraging people to protect houses located near water sources (rural houses), encouraging people to use protection on wells could create protection to prevent drowning.

In the findings of the present study, similar to the study of Guevara et al. [24], the measures related to the prevention of drowning deaths were investigated, and things under the heading of drowning prevention, such as redesigning or covering the heads of rural wells and using barriers to preventing people from entering unsafe canals or dams were presented. In Yang et al.'s study [28], protective fences or warning signs were not found around the accident sites, and this shows the necessity of using protection to prevent accidents that are consistent with our findings.

4.4. Preventive measures suggested at the family level

Based on the findings of this study, the respondents made the following suggestions that can be taken to protect people at risk in different ways. They include things such as the expansion of swimming training programs in primary schools, familiarity with the techniques of swimming, and its basic principles that have a significant relationship with reducing the drowning rate. Moreover, awareness of parents regarding the need for children to be monitored inside and outside the home can be done through training such as establishing childcare mechanisms or forming teams of parents to take care of children in rural communities (especially during harvest). Also, to teach children to avoid entering streams and rivers with fast water flow and swimming alone.

4.5. Preventive measures suggested at the community level

Training or forcing the use of personal protective equipment in boats, training lifeguards for continuous monitoring in swimming areas, harmonizing flags and symbols related to safe beaches and educating people about their importance, increasing people's access to public swimming pools, teaching swimming to the general population under lifeguard supervision. Teaching and forcing others to avoid drinking alcohol while boating or around water intake is one of the things that were included in this category. Among the other findings obtained in this study was the limitation of damage, which can increase the survival of drowning victims by educating the general public about the basic principles of resuscitation and starting a public mobilization for resuscitation or timely resuscitation by ordinary and non-specialized pAe. In a study by Musaibi et al. [27], demonstrated that the absence of vital signs at the time of arrival at the hospital was one of the important factors in the investigations, and performing cardiopulmonary resuscitation on site and continuing it in the hospital could create a greater chance for the recovery of drowning children. Therefore, teaching resuscitation to parents and children's relatives can be effective in saving people from drowning deaths. The findings of the present study are consistent with the study conducted by Sarassat et al. [21] in the field of planning strategies to prevent drowning by training which requires a better understanding of subpopulations that are at risk such as parents that should receive more training to increase their awareness in the field of supervision and care of children to prevent drowning. Similarly, in the study of Rahman et al. [30], the importance of teaching swimming techniques to children and the importance of teaching resuscitation to parents and teachers of children was discussed. In the study by Wilcox et al. [25] in Australia, swimmers who are not familiar with the environment, around rocks, and often in rivers, were more likely to drown compared to people who knew better swimming skills and were familiar with the environment.

Therefore, our study is consistent with it and this makes clear the high importance of swimming skill training for people. In the study of Livy et al. [26], the prevention strategies included teaching swimming skills, using technology in times of need, and environmental skills and short-term positive effects and significant behavior change were observed in the use of life jackets, of which our study is aligned. It was also stated in both studies that the complexity of issues surrounding drowning requires robust data collection and evaluation of preventive measures to support the development of targeted and tailored prevention interventions and that drowning is a serious public health issue and should be prioritized like other public health priorities. In Yang et al.'s study [28], none of the children's caregivers knew how to perform CPR. For children under 5 years of age, significant risk factors included the caregiver's poor health, lack of use of flotation devices, and lack of proper swimming training. For children aged 5–14 years, the main risk factors were that the child did not experience regular play near or in water and lack of close supervision, and our study was similar to these findings. Also, the risk factors identified in this study showed that childhood drowning can be prevented by providing safety education programs, which should focus on continuous adult supervision and the use of flotation devices when children play in and near water in rural areas in the countries to prevent from developing.

In final, in terms of knowledge of both medical and non-medical personnel groups, the FGDs appeared to be well aware of drowning prevention measures but they rarely take any preventive measures. The gap between the knowledge and behavior may be due to situation culture and these events are accepted as natural then resulting in a lack of any effort taken at three-level, family, community, or infrastructure.

4.6. Limitations of the study

If people were not interested in participating in the meetings, they were removed and their replacements were introduced. The findings reported by the local medical and nonmedical personnel in the focus groups may not be generalizable to other regions, and also the focus groups' experiences and suggestions have not been validated in their setting.

5. Conclusion

The Haddon matrix can be used in the qualitative research method, both in the data collection stage and in the data analysis stage. This study, using the Haddon matrix as a qualitative study method, obtained useful information about the injuries caused by drowning and effective strategies for preventing drowning, which will be useful for future research. We investigated the main reasons for the injury in two major risk groups including young boys and teenagers and then children and the, and according to Haddon's strategy, solutions were presented, which mainly require interdisciplinary activities with a greater focus on these two groups. It is to eliminate the defects and prevent the recurrence of possible future incidents and can be a practical guide for the planning of the relevant organizations.

Author contribution statement

Ali Davoudi-Kiakalayeh: Conceived and designed the experiments; Performed the experiments; Contributed reagents, materials, analysis tools or data.

Jalal Barshan; Faezeh Emami Sigaroudi: Analyzed and interpreted the data; Wrote the paper.

Hamed Mousavi Mirak: Performed the experiments; Wrote the paper.

Seyed Ahmad Naseri Alavi: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Data availability statement

Data will be made available on request.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

References

[1] E.F. van Beeck, C.M. Branche, D. Szpilman, J.H. Modell, J.J. Bierens, A new definition of drowning: towards documentation and prevention of a global public health problem, Bull. World Health Organ. 83 (11) (2005) 853–856. Epub 2005 Nov 10. PMID: 16302042; PMCID: PMC2626470.

[2] A.H. Idris, R.A. Berg, J. Bierens, L. Bossaert, C.M. Branche, A. Gabrielli, S.A. Graves, A.J. Handley, R. Hoelle, P.T. Morley, L. Papa, P.E. Pepe, L. Quan, D. Szpilman, J.G. Wigginton, J.H. Modell, American Heart Association, Recommended guidelines for uniform reporting of data from drowning: the "Utstein style", Circulation 108 (20) (2003) 2565–2574, https://doi.org/10.1161/01.CIR.0000099581.70012.68. PMID: 14623794.

[3] World Health Organization (2021) Drowning. https://www.who.int/en/news-room/fact-sheets/detail/drowning Accessed 27 May 2021 [Internet]. Available from: https://doi.org/10.1007/s00414-022-02783-4.

[4] D.R. Meddings, J.P. Scarr, K. Larson, J. Vaughan, E.G. Krug, Drowning prevention: turning the tide on a leading killer, Lancet Public Health 6 (9) (2021) e692–e695, https://doi.org/10.1016/S2468-2667(21)00165-1. Epub 2021 Jul 24. PMID: 34310906; PMCID: PMC8391011.

[5] A. Rahman, S.R. Mashreky, S.M. Chowdhury, Analysis of the childhood fatal drowning situation in Bangladesh: exploring prevention measures for low-income countries, Inj. Prev. 15 (2009) 75–79.

[6] R.C. Franklin, A.E. Peden, E.B. Hamilton, C. Bisignano, C.D. Castle, Z.V. Dingels, S.I. Hay, Z. Liu, A.H. Mokdad, N.L.S. Roberts, D.O. Sylte, T. Vos, G.G. Abady, A. E. Abosetugn, R. Ahmed, F. Alahdab, C.L. Andrei, C.A.T. Antonio, J. Arabloo, A.A.K. Arba, A.D. Badiye, S.M. Bakkannavar, M. Banach, P.C. Banik, A. Banstola, S. L. Barker-Collo, A. Barzegar, M. Bayati, P. Bhardwaj, S. Bhaumik, Z.A. Bhutta, A. Bijani, A. Boloor, F. Carvalho, M.A.K. Chowdhury, D.T. Chu, S.M. Colquhoun, H. Dagne, B. Dagnew, L. Dandona, R. Dandona, A. Daryani, S.D. Dharmaratne, Z.S. Dibaji Forooshani, H.T. Do, T.R. Driscoll, A.W. Eagan, Z. El-Khatib, E. Fernandes, I. Filip, F. Fischer, B. Gebremichael, G. Gupta, J.A. Haagsma, S. Hassan, D. Hendrie, C.L. Hoang, M.K. Hole, R. Holla, S. Hostiuc, M. Househ, O. S. Ilesanmi, L.R. Inbaraj, S.S.N. Irvani, M.M. Islam, R.Q. Ivers, A.U. Jayatilleke, F. Joukar, R. Kalhor, T. Kanchan, N. Kapoor, A. Kasaeian, M. Khan, E.A. Khan, J. Khubchandani, K. Krishan, G.A. Kumar, P. Lauriola, A.D. Lopez, M. Madadin, M. Majdan, V. Maled, N. Manafi, A. Manafi, M. McKee, H.G. Meles, R. G. Menezes, T.J. Meretoja, T.R. Miller, P. Mithra, A. Mohammadian-Hafshejani, R. Mohammadpourhodki, F. Mohebi, M. Molokhia, G. Mustafa, I. Negoi, C. T. Nguyen, H.L.T. Nguyen, A.T. Olagunju, T.O. Olagunju, J.R. Padubidri, K. Pakshir, A. Pathak, S. Polinder, D.R.A. Pribadi, N. Rabiee, A. Radfar, S.M. Rana, J. Rickard, S. Safari, P. Salamati, A.M. Samy, A.R. Sarker, D.C. Schwebel, S. Senthilkumaran, F. Shaahmadi, M.A. Shaikh, J.I. Shin, P.K. Singh, A. Soheili, M. A. Stokes, H.A.R. Suleria, I.U. Tarigan, M.H. Temsah, B.E. Tesfay, P.R. Valdez, Y. Veisani, P. Ye, N. Yonemoto, C. Yu, H. Yusefzadeh, S.B. Zaman, Z.J. Zhang, S. L. James, The burden of unintentional drowning: global, regional and national estimates of mortality from the Global Burden of Disease 2017 Study, Inj. Prev. 26 (Supp 1) (2020) i83–i95, https://doi.org/10.1136/injuryprev-2019-043484. Epub 2020 Feb 20. Erratum in: Inj Prev. 2020 Sep 28;: PMID: 32079663; PMCID: PMC7571364.

[7] D. Szpilman, M. Tipton, J. Sempsrott, J. Webber, J. Bierens, P. Dawes, et al., Drowning timeline: a new systematic model of the drowning process, Am. J. Emerg. Med. 16 (1) (2016) 1–10.

[8] R.C. Franklin, Improving pool fencing legislation in queensland , Australia : attitudes and impact on child drowning fatalities, Publ. Health 14 (12) (2017) 1–15.

[9] D.H. Taylor, R.C. Franklin, Aquatic competencies and drowning prevention in children 2 – 4 years: a systematic review, Saf. Now. 6 (2) (2020) 1–15.

[10] H. Ahmad, Coastal zone management Bangladesh coastal zone management status and future trends, J Coast Zo Manag 22 (1) (2019) 466–474.

[11] R. Sindall, T. Mecrow, A.C. Queiroga, C. Boyer, W. Koon, A.E. Peden, Drowning risk and climate change: a state-of-the-art review, Inj. Prev. 28 (2) (2022) 185–191.

[12] J. Nouri, A.R. Karbassi, S. Mirkia, Environmental management of coastal regions in the Caspian Sea, Int. J. Environ. Sci. Technol. 5 (1) (2008) 43–52.
[13] F.O. Al-Qurashi, A.A. Yousef, A. Aljoudi, S.M. Alzahrani, N.Y. Al-Jawder, A.K. Al-Ahmar, et al., A review of nonfatal drowning in the pediatric-age group: a 10-year experience at a university hospital in Saudi arabia, Pediatr. Emerg. Care 35 (11) (2019) 782–786.
[14] W. Haddon, The changing approach to the epidemiology, prevention, and amelioration of trauma: the transition to approaches etiologically rather than descriptively based, Health Public J. Am. 58 (1) (1968) 1431–1438.
[15] D.J. Barnett, R.D. Balicer, D. Blodgett, A.L. Fews, C.L. Parker, J.M. Links, The Application of the Haddon Matrix to Public Health Readiness and Response Planning, 113(5), 2005, pp. 561–566.
[16] I. Vriend, V. Gouttebarge, C.F. Finch, W Van Mechelen, E.A.L.M. Verhagen, Intervention strategies used in sport injury prevention studies: a systematic review identifying studies applying the Haddon matrix, Sports Med. 47 (10) (2017) 2027–2043.
[17] L.M. Cortés, S.W. Hargarten, H.M. Hennes, Recommendations for water safety and drowning prevention for travelers, J. Trav. Med. 13 (1) (2006) 21–34.
[18] B.A. Wallis, K. Watt, R.C. Franklin, M. Taylor, J.W. Nixon, R.M. Kimble, Interventions associated with drowning prevention in children and adolescents: systematic literature review, Inj. Prev. 21 (3) (2015) 195–204.
[19] H. Aghayari, L.R. Kalankesh, H. Sadeghi-Bazargani, M.R. Feizi-Derakhshi, Mobile applications for road traffic health and safety in the mirror of the Haddon's matrix, BMC Med. Inf. Decis. Making 21 (1) (2021) 1–12.
[20] İ. Öztürk, P. Biçaksiz, Y. Üzümcüoğlu Zihni, T. Özkan, The investigation of Turkey's road safety decisions by Haddon matrix and 7Es, Türkiye Halk Sağlığı Derg. 19 (3) (2021) 196–210.
[21] S. Sarrassat, S. Mrema, K. Tani, T. Mecrow, D. Ryan, S. Cousens, Estimating drowning mortality in Tanzania: a systematic review and meta-analysis of existing data sources, Inj. Prev. 25 (5) (2019) 459–471.
[22] A. Anparasan, M. Lejeune, Analyzing the response to epidemics: concept of evidence-based Haddon matrix, J. Humanit. Logist. Supply Chain Manag. 7 (3) (2017) 266–283.
[23] A. Davoudi-kiakalayeh, R. Mohammadi, S. Yousefzade-Chabok, B. Jansson, Evaluation of a community-based drowning prevention programme in northern Islamic Republic of Iran, East. Mediterr. Health J. 19 (7) (2013) 629–637.
[24] J.P. Guevarra, R.C. Franklin, J.A. Basilio, L.L. Orbillo, J.J.L. Go, J.P. Guevarra, et al., Child drowning prevention in the Philippines : the beginning of a conversation, Int. J. Inj. Control Saf. Promot. 22 (3) (2015) 243–253.
[25] S. Willcox-Pidgeon, R.C. Franklin, P.A. Leggat, S. Devine, Epidemiology of unintentional fatal drowning among migrants in Australia, Aust. N. Z. J. Publ. Health 45 (3) (2021) 255–262.
[26] J.E. Leavy, G. Crawford, L. Portsmouth, J. Jancey, F. Leaversuch, L. Nimmo, et al., Recreational drowning prevention interventions for adults, 1990–2012: a review, J. Community Health 40 (4) (2015) 725–735.
[27] Z. Mosayebi, A.H. Movahedian, G.A. Mousavi, Drowning in children in Iran : outcomes and prognostic factors, Med. J. Malaysia 66 (3) (2014) 187–190.
[28] L. Yang, Q.-Q. Nong, C.-L. Li, Q.-M. Feng, S.K. Lo, Risk factors for childhood drowning in rural regions of a developing country: a case–control study, Inj. Prev. 1 (1) (2007) 178–183.
[29] P. Suominen, C. Baillie, R. Korpela, S. Rautanen, S. Ranta, K.T. Olkkola, Impact of age , submersion time, and water temperature on outcome in near-drowning, Resuscitation 52 (1) (2002) 247–254.
[30] A.F. Rahman, S. Bose, Cost-effectiveness of an injury and drowning prevention program in Bangladesh, Pediatrics 130 (6) (2012) 1621–1629.