Types of Behavior of Flood Victims around Floodwaters. Correlation with Situational and Demographic Factors

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Abstract: Recently, human behavior around floodwaters has been acknowledged as one of the factors that influence the risk of fatal incidents. The present study analyzes the behavior of flood victims by developing a systematic classification of their actions at the time of the flood. Based on this taxonomy, the study examines a flood fatality database for Greece (1960–2019) to quantify the different types of behavior and to examine potential correlations with various demographical and situational factors. Results show that three-quarters of the victims exhibit a risk-taking behavior by deliberately coming in contact with floodwaters. Statistically significant associations were found between behavior and the demographics of the victims, the type surrounding environment, and the use of vehicles, indicating that certain situations and certain individuals are more prone to risk-taking behaviors than others. A statistical model shows that the behavior of a flood victim can be predicted with high accuracy by knowing certain variables of a fatal incident. The prevalence of risk-taking actions identified is a strong indication that human behavior is a crucial factor in flood mortality. The present study shows that a systematic classification of behaviors can help future interventions by highlighting the most common mechanisms of fatal incidents.

Keywords: behavior; flood fatalities; flood mortality; risk-taking; flood deaths; victim actions

1. Introduction

Floods are one of the most deadly types of natural disasters, inducing a large number of fatalities [1–3], significant economic damages [4], and a diversity of adverse consequences [5,6]. Especially regarding extreme flood events, studies have shown that they have the potential to cause large numbers of fatalities [7,8].

A number of previous works have studied the effects of floods on human health [9] by examining datasets extracted by multiple floods [2] or by focusing on a case study of a catastrophic flood [10]. Their findings provide interesting insights into how these factors influence the risk to individuals during a flood event. Such factors include victim demographics [2,11,12], victim activities at the time of the accident [13], the use of motor vehicles [14], different causes of death [13,15], and various social and situational details [16] that have been studied in both descriptive fashion [17,18] or on a statistics-based, more systematic way [12].

One of the factors that have been discussed in a small fragment of this literature is the behavior of individuals against the imminent risk of flooding. In these studies, there is multiple evidence of dangerous or risk-taking behaviors [1,16,18–22]. For instance, there are reports of individuals ignoring or even removing relevant warning signs [23], as well as standing dangerously close to raging water to observe the phenomenon [1]. Staes [24] reported cases of victims that decided to enter floodwaters despite warnings of bystanders and official personnel by removing or driving around roadblocks and barricades. Coates [11] and Diakakis et al. [10] report incidents, during which
individuals entered floodwaters pursuing recreational interests, suggesting that the behavior of certain victims indicates a lack of understanding of inherent dangers. Driving into flooded waterways has been also acknowledged in numerous works [14,23].

A group of studies, using a well-established theoretical framework from the behavioral sciences, such as the Theory of Planned Behavior [25], have attempted to explain why people drive into or avoid floodwaters [23,26]. These studies show that decisions of individuals are mostly psychological in nature, and are influenced by several factors, including self-efficacy beliefs, social influence, risk perception, past experiences and behaviors, and other personal attributes [26,27]. In this field, studies using mostly surveys and experimental data to provide very useful insights that can be exploited to shape effective behavioral interventions [23,26–30].

However, although the risk-taking attitude has been acknowledged for over two decades in the literature [11,24], and there are strong indications that there are numerous cases in which victims’ actions are incautious until today, there is no consensus in the literature on standardized terminology or classification for this type of behavior. Previous works use different terms to name it, such as “unnecessary”, “risk-taking” [13,21,31], “dangerous” [21], “inappropriate” [31], or call it “misconduct” [32], and the deaths associated with it “avoidable” [27]. In addition, while a small number of studies [1,30,33,34] refer to certain types of dangerous behaviors and identify specific motivations or reasoning for them, there are only a few that divide these motivations into categories. Becker et al. [30] and Hamilton et al. [28] group risk-taking behaviors into types including rescues, recreation, attempts to reach a destination, protecting a property, and others. These studies focus mostly on risk-taking attitudes and discuss a diverse set of explanations and motivations around them. Protective behaviors have received less attention despite the interesting findings the relevant studies provide [29].

Furthermore, to this day, there is limited research on a systematic and quantified way of recording the different types of risk-taking and non-risk-taking behaviors identified [28,30] or explained through behavioral studies [23,26] in the relevant literature. Due to an overall lack of empirical evidence on the behavioral aspect of fatal flood incidents (see, for example, in Petrucci et al. [1]), in a number of the existing mortality studies, the general activity of victims [not their actions] is discussed as an indicator, in order to draw conclusions on their behavior. Some of these activities (e.g., surfing in floodwaters) indeed provide evidence of taking risks. However, there are others (e.g., camping), for which it is not clear whether the victim acted in an inappropriate, careless, or risk-taking manner.

In addition, there is only sporadic evidence on how common the different types of actions and motivations behind these types of behaviors are, despite the large body of flood mortality studies. Furthermore, the literature has explored, to a very limited extent, empirical evidence [10][35] on whether and how the different types of behavior or actions correlate with situational variables or the demographic of the victims. These correlations can be particularly useful to provide insights on how these incidents occur, what types of dangerous situations develop, and how they could be avoided by more targeted interventions. In fact, existing literature invites further research on the motives and behaviors of flood victims [20,30], stressing that there is ‘dearth of knowledge’ on the reasons for which people engage in risk-taking behaviors [23,27].

A more direct way to determine a victim’s behavior would be to acquire information on their reported actions and reported intentions at the time of the flood and leading up to the incident that each victim was involved. These actions can be valuable in reflecting the victims’ decision making, especially at a time when options were available, rather than at a time when a person has been already trapped or carried away by floodwaters. Addressing this issue, Diakakis et al. [10] develop a two-group categorization of flood victims, distinguishing between individuals who approached floodwaters while in safety, and persons who found themselves in a position where their safety was gradually reducing. Diakakis et al. [10] referred also to nine different types of motivations by analyzing victim actions during a catastrophic flood in Greece.

In this context, this work aims to explore the behavior of victims during floods as reflected by their actions, by developing a classification system that includes behavioral elements reported in the
relevant literature. Then, the present study applies this classification system to a flood fatality database for Greece, exploiting reports on their reported actions and intentions during the incidents. Through this approach the study aims:

(a) To provide a standardized, systematic classification of the different attitudes or behaviors;
(b) to quantify the extent of risk-taking behaviors amongst flood victims; and
(c) to examine potential correlations of behavior with other situational, environmental, and demographic factors.

2. Proposed Classification System

2.1. Proposed System

The basic distinction made in the literature, regarding behavior around floodwaters, is whether a victim took a voluntary risk or not. Following this very division, the proposed system divides the victims into “active” and “passive” cases and introduces the following two major groups of behavior.

(i) Deliberately Active Cases Group (DA group): This group includes the victims who deliberately and/or voluntarily came in contact with floodwaters as a result of their decision(s). The victims of this group were in an initial position/location, in which they were safe as these decisions were made. It includes people who were passengers in vehicles that were driven by others and engaged with floodwaters as a result of actions and decisions made by someone else (the driver), that nonetheless belong to the sphere of deliberate contact. In these situations, it is very often not clear whether the victim was part of the decision making or played a role in it. For example, in one incident in 1997, passengers of a bus traveling on the motorway were drowned, when the vehicle crossed an inundated part of the road after a flash flood near the city of Corinth in Greece [36], and their fate was largely defined by a “DA group” behavior of the driver. This group also includes individuals that refused to evacuate and declined an option to avoid danger, despite receiving a direct warning, or individuals that decided to delay the evacuation temporarily to protect their property or retrieve something.

(ii) Passive Cases Group (P group): This group includes the victims that came in contact with floodwaters inadvertently or were forced by the circumstances (e.g., trapped in a building) while at their initial position, safety was compromised or the level of safety was in decline. Victims of this category can be people with mobility problems or individuals generally unable to flee from danger. This category does not include victims that received and ignored a warning or refused to evacuate.

Table 1 offers a detailed description of each group and provides the basic motivations and reasoning of the behavior, splitting each group into subcategories expressing distinct motivations. It also provides a body of previous studies that describe examples or contain references to the listed types of behavior and actions.

Normally, most of the empirical evidence associated with a flood victim’s actions or behavior are descriptive in nature [22] and are available mostly as narratives [16] similar to an eyewitness account. This evidence can be in a non-standardized form across different datasets and sometimes even within the same dataset. This is reflected in the different categorizations of behavior types seen in recent studies [1,28]. To deal with the documentary nature of part of the evidence, particular attention was paid to using objective criteria to distinguish between different groups of behavior. For example, distinguishing between ‘traveling across floodwaters to reach a destination’ and ‘entering floodwaters in an effort to save someone’ would not be subject to the reporter’s opinion, but a distinction of intentions based on facts. Thus, the boundaries of the behavior groups proposed in the present study are defined by distinct factors (i.e., the victim’s actions and decisions) that are mostly present in typical flood mortality datasets. In this way, the classification proposed can function with the descriptive nature of these type of datasets.
Table 1. Classification of behaviors in groups and different actions, motivations, or reasoning for victim actions.

| Group Name | Main Characteristics of Behavior | Code * | Reported Actions/Motivation/Reasoning for Victim’s Actions | Awareness of Threat | Behavior/Motivation Recorded or Mentioned in Literature |
|------------|----------------------------------|--------|----------------------------------------------------------|---------------------|--------------------------------------------------------|
| DA1        | Deliberately Active (DA)         |        | Enter floodwaters voluntarily to travel across/reach a destination | a                   | Haynes et al. [37], Sharif et al. [34]                 |
| DA2        |                                   |        | Enter floodwaters voluntarily to retrieve property/animals | a                   | Jonkman and Kelman [13], Wilson [33], Ruin et al. [18] |
| DA3        |                                   |        | Enter floodwaters voluntarily to rescue/assist someone | a                   | Wilson [33], Haynes et al. [37]                        |
| DA4        |                                   |        | Stand/Walk/Drive at the boundary of floodwaters or on a bridge to observe (“flood tourism”) | a                   | Jonkman and Kelman [13], Ruin et al. [18], Wilson [33] |
| DA5        |                                   |        | Enter floodwaters due to occupational duty | a                   | Haynes et al. [37]                                    |
| DA6        |                                   |        | Enter floodwaters voluntarily for recreational purposes | a                   | Jonkman and Kelman [13], Haynes et al. [37], FitzGerald et al. [31] |
| DA7        |                                   |        | Enter floodwaters to check flood damage | a                   | Petrucci et al. [1] [2019], Ahmed et al.               |
| DA8        |                                   |        | Enter floodwaters as passenger of vehicle in which somebody else is driving | b                   | Lekkas et al. [36]                                    |
| DA9        |                                   |        | Decision to stay/refuse evacuation to protect property or person | a                   | Rosenthal and Bezuyen [38], Wilson [33]               |
| DA10       |                                   |        | Decision to delay evacuation temporarily to protect property/person or to retrieve something | a                   | Wilson [33]                                           |
### 2.2. Application in Greece

To demonstrate the use of the proposed classification system, this work exploits a database of 258 flood fatalities in Greece, developed by Diakakis and Deligiannakis [22], covering the period 1960–2019, also used by Diakakis [39] and Pereira et al. [40]. The database contains deaths caused directly or indirectly by floods during the study period across the Greek territory.

The database was developed using evidence collected from a variety of sources, including official information from the Greek Fire Service, police reports, scientific publications, and press articles (Table 2).

|   | Decision to stay at location as the most safe option | a | Diakakis et al. [10] |
|---|----------------------------------------------------|---|----------------------|
| P1 | Contact with or approach to floodwaters is not deliberate (i) | Aware of risk, but impossible to evacuate due to physical condition (i.e., immobile, bedridden, and others) | a | Ruin et al. [18], Vinet et al. [21] |
| P2 | Before contact, the victim is in an initial position where safety is compromised or safety levels are reducing (ii) | Unaware of risk until impossible to evacuate/or until accident happened | b | Diakakis et al. [10] |
| P3 | Have not received any warnings (iii) | Enter waterbody unaware of flood/before flood occurs | b | Diakakis et al. [10] |
| P4 | Enter floodwaters while fleeing from danger | a | Haynes et al. [37] |

* Abbreviation code. a: Aware before taking action. b: Unaware of threat.
Table 2. Sources of flood fatality information (1960–2019), along with the type of data provided by each source.

| Sources             | Form of Evidence                                      | Details                                                                 |
|---------------------|-------------------------------------------------------|-------------------------------------------------------------------------|
| Greek Fire Service  | Press releases, incident bulletin archives, incident reports | Brief account of the incidents, containing location information and details on the victims. |
| Hellenic Police     | Press releases, incident reports                      | Detailed account of the incidents, containing location information and details on the victims and their actions. |
| Scientific publications | General descriptive incident accounts [10,41–46] | Brief accounts of the incidents with details on the circumstances under which the incidents occurred |
| Press articles      | 250 press articles from 12 national newspapers [47,48] | Detailed accounts of the incidents, containing location information, visual material, occasionally eyewitness accounts, and information on the victims and their actions |

The reports collected from the above sources contained specific evidence on the demographics of the victims, the locations that the incidents occurred, and detailed accounts of the events along with information on the surrounding environment. These accounts were provided mostly by emergency responders and were stored in archives or made public in press releases by the relevant authorities. In addition to the official reports, the press published independent accounts of the incidents. These narratives, derived from reporters’ accounts and/or from interviews with witnesses and family members that in some cases were included verbatim in the articles, describing the timeline of events. These accounts contained information on the actions and the initial intentions of the victims, as reported by observers that in the present study were used to identify elements of their behavior based on the criteria set on the proposed system.

As it is described above, the classification system was developed in a way that the boundaries of different groups were defined by objective factors (i.e., the victim’s actions and decisions), introduced to make different categories of behavior distinguishable through these incident accounts. However, to ensure the accuracy and reliability of the data, information was included in the database only in the case that it was consistent among two or more independent sources.

Each entry of the database corresponded to one fatality. Each fatality was described by variables that were used to define the circumstances and the surrounding environment in which the fatal incidents occurred, as well as the actions and the demographics of the victims. All the fatalities included were directly attributable to flooding. Indirect fatalities (e.g., deaths occurring during clean-up or post-flood car accidents due to malfunctioning traffic lights) and long-term health effects were not included in this analysis.

For the purposes of the present analysis, each fatality was given a classification or a value in the following variables:
1. Reference number
2. Location of the incident
3. Date
4. Time of day (whether the incident occurred in daylight or night-time)
5. Demographic details of the victim (age and gender)
6. Surrounding environment (inside or outside the urban fabric)
7. Immediate surroundings (incident occurring indoors or outdoors)
8. Activity of the victim
9. Magnitude of the flood event (high mortality > 10 deaths or low mortality < 10 deaths) (using the classification suggested by Vinet et al. [49])
10. Use of a vehicle during the time of the incident (yes/no)
11. Behavior of the victim based on the categories listed in Table 1.

To examine associations or patterns among different variables, bivariate analyses were carried out. Chi-square tests of independence [50] were used to examine potential associations between the behavior of victims (classified according to Table 1) and their age and gender, as well as the type of surrounding environment, the immediate surroundings, the magnitude of the flood event, and the use of a vehicle during each incident. In addition, binary logistic regression tests were performed, to further understand the predictive ability of various factors on behavior and the extent of their association. In this binary logistic regression test, the behavior of victims was treated as a binary dependent variable (i.e., risk-taking or non-risk-taking) and the rest of the factors of the dataset as independent variables (predictors)[51].

The level of confidence of all statistical analyses was 5%. Statistical analyses were carried out with the aid of SPSS Version 22 [52].

3. Results

From a total of 258 fatalities in the database, information on behavior was found for 173 cases. In 78 cases, victim actions or intentions were not accurately known. For seven individuals, death was an indirect effect of the flood (e.g., accidents occurring during clean-up) and therefore, they were not included in this analysis.

Amongst the 173 fatalities, a sum of 127 (or 73.4%) can be categorized in the spectrum of “deliberately active” behavior, out of which a large part (74) consisted of people that voluntarily entered floodwaters to reach a destination (45) and stood/walked/drove at the boundary of floodwaters (29). In addition, 34 victims lost their lives as passengers in vehicles that entered floodwaters while someone else was driving. On the other hand, a total of 44 (25.4%) victims exhibited a passive behavior, out of which a large portion (24) was unaware of the flood threat until it was impossible to evacuate. Other types of passive behaviors were identified as well in smaller percentages (Figure 1).
Figure 1. Distribution of flood fatalities in Greece (1960–2019) per type of behavior (n = 173). The blue colors denote the deliberately active (DA) group, while the red colors represent the passive behavior (P) group.

Amongst the 173 cases, the DA1 group (victims that entered floodwaters voluntarily to travel across/reach a destination) came first, followed by the DA8 group (victims that entered floodwaters as passengers of vehicles in which somebody else was driving). Both types of incidents were essentially caused by someone trying to enter/travel across a watercourse from a safe initial position. Individuals who approached and stood/walked or drove at the boundary of floodwaters (DA4 group) came third. Group P3 was the fourth most common category.

Overall, incidents that occurred as a result of a deliberately active behavior, with victims moving into or approaching floodwaters from an initial position of safety (DA1–DA8) sums up to 73.4% of the total known cases. On the other hand, incidents that belong to the realm of passive behaviors (P1–P5), in which the victims were found in a position of reducing safety levels, aggregate a total of 25.4% (i.e., approximately one-quarter of the total).

3.1. Surrounding Environment

With respect to the surroundings in which the studied incidents occurred, it was found that the active behaviors (DA1–DA10) were exhibited mostly in outdoor environments. More specifically, out of 129 such cases, 123 occurred outdoors, only 2 indoors, and in 2 cases, the immediate surroundings are not known. On the contrary, passive behavior fatalities (P1–P5) exhibited a different regime, with 35 indoor and 9 outdoor incidents (Table 3). A Chi-square test (N = 171) performed to examine the independence between the victims’ behavior and the immediate surroundings showed a statistically significant difference between the two groups (i.e., indoors and outdoors incidents), indicating an association between the two variables.

Table 3. Distribution of flood fatalities in Greece (1960–2019), with respect to the victims’ behavior group and the immediate surroundings of the incidents (n = 171).

| Deliberately Active Group (DA1–DA10) | Passive Group (P1–P5) |
|-------------------------------------|-----------------------|
| Occurred indoors                    | 4                     | 35                    |
| Occurred outdoors                   | 123                   | 9                     |
| Not reported                        | 2                     | 0                     |

With regard to the general environment that an incident occurred (urban or rural), it was found that active behaviors (DA1–DA10) occur mostly in a rural environment. On the other hand, passive behaviors appear mostly in urban environment fatalities (Table 4). A Chi-square test (N = 170) performed to examine the independence between behavior and the environment that incidents occurred showed a statistically significant difference between the two variables.
Table 4. Distribution of flood fatalities in Greece (1960–2019), with respect to victims’ behavior and the environment they occurred (n = 170).

|                             | Deliberately Active Group (DA1–DA10) | Passive Group (P1–P5) |
|-----------------------------|--------------------------------------|-----------------------|
| Occurred in urban environment | 33                                   | 31                    |
| Occurred in rural environment | 93                                   | 13                    |
| Not reported                | 3                                    | 0                     |

Chi-Square = 27.220, p = 0.000.

3.2. Victim Demographics

The examination of victims’ gender shows differences in the male/female ratio when considering different types of behaviors. In the active behavior groups, males are the vast majority of victims (Table 5), with the ratio calculated at 3.6 to 1. In the group of victims that belong to the passive behavior category, males are again the majority, but with a much lower ratio (approximately 1.4 to 1). A Chi-square test of independence (Chi-square = 5.789, p = 0.024) showed a statistically significant association between the behavior and the gender of victims.

The victims who belong to the DA8 group (passengers of vehicles that someone else was driving) were not included in the gender analysis, given that it is not clear if they were part of the decision-making process to enter floodwaters. Therefore, there is no value in examining whether their gender played a role in decision making.

Table 5. Distribution of flood fatalities in Greece (1960–2019), with respect to victims’ behavior and their gender (n = 136).

|                             | Deliberately Active Group (DA1–DA10 *) | Passive Group (P1–P5) |
|-----------------------------|----------------------------------------|-----------------------|
| Male                        | 72                                     | 26                    |
| Female                      | 20                                     | 18                    |
| Ratio (M to F)              | 3.6 to 1                               | 1.4 to 1              |

* DA8 fatalities are excluded in this analysis. Chi-square = 5.789, p = 0.024.

Concerning the age of the victims (except for the DA8 group as above), it was found that individuals that passed away in incidents characterized by active behaviors were in average younger by a significant margin than the ones that died exhibiting a passive behavior (44 against 63.2 respectively). The difference between active and passive behavior cases, in terms of distribution in age groups, is evident in Figure 2. This distribution shows that especially in the higher age groups, there are discrepancies between active behavior and passive behavior victims. In detail, in the 0–80 years old range, active groups are overrepresented, whereas the contrary is recorded for the >80 age group.
3.3. Timing of Incidents

Concerning the time of day that incidents occurred (in daylight or nighttime), performing a Chi-square test (n = 136) showed no significant differences \( (p = 0.682) \) in the ratio between passive and active behaviors (Table 6), indicating that it is not a factor associated with victims’ attitude against the imminent risk.

Table 6. Distribution of flood fatalities in Greece (1960–2019), with respect to the victims’ behavior group and the time of occurrence (nighttime/daylight) (n = 136).

| Deliberately Active Group (DA1–DA10 *) | Passive Group (P1–P5) |
|---------------------------------------|----------------------|
| Nighttime                             | 45 (42.9%) **        |
| Daylight                              | 60 (57.1%)           |
|                                       | 15 (48.4%)           |

* The victims that belong to the DA8 group were not included in the gender analysis. ** Percentage (in brackets) refers to the cases for which timing of the incident is known.

3.4. Use of Vehicles

In relation to the use of vehicles, it was found that the majority of fatalities belonging to the active behavior groups were vehicle-related. On the contrary, only a small number of passive-behavior fatalities involved a vehicle (Table 7). The difference in the distribution of victims in these two groups was found to be statistically significant by means of a chi-square test (Chi-Square = 35.914, \( p = 0.000 \)).
3.5. Magnitude of the Event

As far as the mortality-magnitude of the flood event is concerned, we used the threshold suggested by Vinet et al. [21]. The comparison showed that high mortality events (>10 fatalities) are characterized by more passive-behavior fatalities than smaller events, leading to an impressively different ratio between the two categories, as shown in Table 8. A Chi-square test (N = 173) performed to examine the independence between the magnitude of events and the behavior of victims showed that the null hypothesis cannot be accepted, and therefore that the difference in the distribution of cases between these two variables is statistically significant.
Table 8. Distribution of flood fatalities in Greece (1960–2019) in high and low mortality events, against victim behavior groups (n = 173).

| Distribution of flood fatalities | Deliberately Active Group (DA1–DA10) | Passive Group (P1–P5) | Ratio (Active to Passive) |
|---------------------------------|---------------------------------------|-----------------------|--------------------------|
| High-mortality events (>10 deaths) | 34                                    | 23                    | 1.5 to 1                 |
| Low-mortality events (<10 deaths) | 95                                    | 21                    | 4.5 to 1                 |

Chi-Square = 9.975, p = 0.002.

3.6. Predictive Ability

Application of a binary logistic regression (BLR) test, showed that the relationship between the victim’s behavior and a combination of factors is relatively strong, allowing the prediction of whether a victim pursued a behavior of the active groups or not, by knowing certain characteristics of an incident.

These characteristics include in binary mode the general environment (urban or rural) of the incident, the immediate surroundings (indoors or outdoors), and the age group of the victim (over or under 70 years old) (Table 9). The importance of these 3 factors, is expressed by the ‘B coefficient’, which is a direct measure of their influence in the equation, indicating the relative influence of a particular independent factor (predictor) to the victim’s behavior.

Table 9. Binary logistic regression (BLR) test results (n = 117).

| Parameter                      | Abbreviation | Sig.  | B     | Exp(B) |
|--------------------------------|--------------|-------|-------|--------|
| General environment            | ENV          | 0.001 | 2.327 | 10.251 |
| Immediate surroundings         | SUR          | 0.000 | 3.385 | 29.508 |
| Age group                      | AGE          | 0.002 | 2.675 | 14.516 |

Nagelkerke R2 equal to 0.741, predictive ability at 89.7%. Hosmer and Lemeshow Test p = 0.764. ENV: General environment. SUR: Immediate surroundings. AGE: Age group of the victim.

Based on this BLR test, the equation is formed as follows:

\[
BEHAVIOR = -4.773 + 2.327ENV + 3.385SUR + 2.675AGE
\]

(1)

where: BEHAVIOR expresses the odds of a risk-taking behavior (i.e., belonging to the deliberately active group) on behalf of the victim (membership for the risk-taking behavior, i.e., risk-taking coded as “1”, whereas passive behavior as “0”). ENV stands for the general environment (Urban or Rural), SUR stands for the immediate surroundings (Indoors or Outdoors), and AGE stands for the age group of the victim (<70 or >70 years old).

The performance of the BLR model was assessed by Nagelkerke R², as a parameter to assess goodness of fit, as well as the prediction accuracy ratio and the Hosmer-Lemeshow test with positive results. The BLR test showed significant predictive ability at an 89.7% rate and a Nagelkerde R² equal to 0.741, indicating a strong coherence for the model. In essence, this means that by knowing the three predictor variables (ENV, SUR, and AGE), we can predict with a relatively good accuracy whether the victim exhibited a behavior that belongs to the active groups or not. For this BLR test, Hosmer and Lemeshow Test showed a value of p = 0.764 accepting the null hypothesis, confirming that of the model.

As described above, in case B coefficient for a factor is positive, then the independent variable affects positively (increases) the probability of the victim in an incident exhibiting a risk-taking behavior that belongs to the DA group (i.e., BEHAVIOR = 1). Thus, the BLR test shows that in the case of incidents that occur in rural areas, the victim is 10.25 times more likely to exhibit a risk-taking
behavior against flood risk than within the urban fabric. In the case of outdoor incidents, victims are 29.5 times more likely to show a risk-taking behavior than in indoor cases, indicating that SUR is the more strongly associated factor. Finally, victims aged less than 70 years old are 14.5 times more likely to exhibit a risk-taking behavior than older victims. Tests carried out with different division of age groups did not show correlation with behavior indicating that in younger individuals (within the <70 years old group) there are no important differences.

4. Discussion

This work develops a classification method to systematically analyze the behavior of flood victims and explore its correlation with other environmental and demographic factors known to have a role in flood mortality. The system classifies victims’ behaviors as reflected by their actions, in a way that it can be applied in flood mortality datasets, given the descriptive nature of the evidence that these datasets usually contain. The system’s use is demonstrated by studying a flood fatality database developed for Greece.

The findings show that the majority of cases (approximately 3 out of 4) involve victim actions that belong to the realm of risk-taking behavior against flood risk (group DA), with individuals leaving safety and coming deliberately in contact with floodwaters. The percentage presented here is particularly high in comparison to certain previous works [2,16], but within the range recorded in them [11,31].

This high percentage is a strong indication that a risk-taking attitude among victims is indeed an important factor in flood mortality, which although it has been acknowledged in previous mortality studies, has not been discussed to the same extent and with the same gravity in comparison to other factors, such as demographical or situational (e.g., the use of vehicle) (see for example Alderman et al. [9]). This can be attributed partly to the lack of relevant data, as it appears for example in Petrucci et al. [1]. These high percentages of deliberate contact with floodwaters indicate that even significant improvements in flood warning technology may not necessarily lead to a significant reduction in human losses, if it is not accompanied with a change in behavior [53].

The systematic categorization of victims’ actions in the present study allows distinguishing between different motivations or mechanisms for coming in contact with floodwaters, even within the same groups of behavior, and indicates that they can differ extensively. For example, coming in contact with water deliberately for “flood tourism”, is very different from entering floodwaters to rescue someone. However, in this study and in previous works [2,16], the data reveal that the majority of active behavior fatalities occur when individuals try to travel across a watercourse to reach a destination, whereas only a small percentage occurs in the course of a rescue. This finding, by highlighting the most common mechanism or motivation of individuals for coming deliberately in contact with floodwaters, can be useful to adapt any future behavioral interventions aiming to reduce risk-taking attitudes [28].

By dividing the behaviors into different groups, the proposed system allows also the exploration of possible associations with other factors. Overall, the associations found between the groups of behavior and the various factors examined in this study indicate that the prevalence of risk-taking behavior is not the same between the different groups of victims or the various environments. In summary, incidents that occur in rural and outdoor environments, especially involving a vehicle, tend to be characterized by risk-taking behaviors at a higher percentage than urban or indoor incidents. In addition, males and younger victims tend to exhibit higher percentages of risk-taking behavior in comparison to females and older victims.

Studies in behavioral science have been successful in identifying certain mechanisms and influencing factors determining the decisions of individuals to enter floodwaters through surveys and experimental data. Recent studies using various theoretical models [27,28] highlight the influence of behavioral, normative, and control beliefs [29] and other factors [28]. For example, Hamilton et al. [23] find a number of attitudinal beliefs, beliefs of social expectations, and self-efficacy beliefs influencing risk-taking behavior.
Several works suggest that a portion of people that decide to enter floodwaters may be aware of the risk and fail to personalize it [26,29,53]. In specific, Sharif et al. [34] and Siegrist and Gutscher [54] suggested that despite being able to envisage the physical risk of the flood, certain individuals cannot imagine the actual negative effects that may occur from the actual flood that they see in front of them. This is confirmed by Hamilton et al. [23], who found that a portion of people tend to believe that the outcome of themselves coming in contact with floodwaters will be “reaching their destination”. Further, Ruin et al. [17] and Hamilton et al. [23] suggest that risk perception may be modified or constrained in the course of a planned activity (acknowledged also in Kellar and Schmidlin [20]) or that simply people do not want to change their planned activities [18].

It has been also proposed that individuals do not appreciate flood warnings as a real threat [14] or as life-threatening [2]. Crossing flooded waterways unharmed in the past or observing other people doing so may also influence their risk perception in some of the cases [20].

The presence or influence of alcohol has also been discussed and even found in flood victims’ blood [24], but it has not been linked systematically to these behaviors in the rest of the literature.

A part of the cases may be associated with strong emotional motivation to rescue a loved one or a pet [27]. Another reason may by over-confidence in their vehicles, devices, or abilities as suggested by [16]. Another explanation for risk-taking is a situation of an individual with conflicting priorities [16] that in a state of emergency lead individuals to irrational decisions. This was apparent in the case of a victim in a 2017 flood in Greece, who after evacuating, changed his mind and returned to his flooded cellar to recover some valuables [10]. As suggested by Terti et al. [16], third parties (e.g., relatives, officials) may have a positive influence in some of these cases by restoring rationality to a person at this state.

The use of vehicles is found to be related to risk-taking behaviors confirming the large percentages of such fatal incidents acknowledged in literature [23,39].

With respect to the association found between behavior and gender of victims, it confirms the suggestion of previous works that males are more likely to pursue a risk-taking behavior than females [20,27]. Hamilton et al. [55] showed significant differences between males and females in risk perception and in reception of behavioral interventions. The extensive difference in the active to passive attitude found between the two genders could also be one of the causes of the respective difference in flood mortality rates identified in Greece [22] and in most areas [1,9]. Indeed, Gissing et al. [56] have found that male drivers tended to exhibit higher percentages in driving into floodwaters than females, while Drabek [57] found that males are more likely to engage in rescues of both loved ones and strangers [27] or try to save their property [11]. In this study, in all incidents involving rescue efforts, the rescuer is a male. In a tragic case in north Greece, a father entered floodwaters to rescue his son and lost his own life as a result.

With regard to the age of victims, the higher percentages of younger people in the active behavior group is in agreement with the findings of Haynes et al. [37] and Ruin et al. [17] and in line with the observations that younger drivers tend to underestimate flood risk [29]. Older individuals are clearly over-represented in the passive behavior group and indoor fatalities, as the most likely population category to get trapped in their homes. Indications of this type of passive behavior have been acknowledged previously also by Jonkman and Kelman [13] who suggested that the elderly may choose to stay in flooded buildings, showing that eight of the nine drownings in buildings involved pensioners in the 1999 floods in France. This pattern can be attributed to various reasons, including immobility problems, not becoming aware of the flood until it is too late, inability to flee due to some physical condition, or reluctance to flee due to emotional attachment [9,11,13,21]. In addition, risk perception of older individuals may be different in comparison to other age groups, given that age has been acknowledged as an influencing factor in perception [58,59]. Older people may have more experiences of past floods as well, which may influence their views and therefore their attitude. However, very distant experiences are not expected to change their perception significantly [60]. The trend of older victims not exhibiting risk-taking behavior is a pattern recorded previously in single flood events as well. For instance, in the case of the 2010 Var flood, 7 out of 13 victims that died indoors were over 80 years old [21]. In a similar case, Diakakis et al. [10] examined
the mortality associated with the catastrophic flood of 2017 Mandra in Greece, finding that the average age of indoor victims was almost 85 years old, as opposed to 52 years old for outdoor decedents. Concerns regarding the challenges of taking shelter indoors in the case of vulnerable individuals have been expressed in previous studies [37].

The evidence presented in this study indicates that a large number, possibly the majority, of flood fatalities can be prevented if the behavior of individuals around floodwaters changes (suggested also by Wilson [33]), that is, if individuals refrain from deliberately entering floodwaters. Therefore, different measures aiming to reduce risk-taking behaviors should be strengthened or even set as a priority depending on local conditions. In addition, the prevalence of risk-taking behaviors among certain environments and groups of individuals suggests that the prevention measures should focus accordingly.

Given that in most cases no warning signs were present (recorded for Greece by Diakakis and Deligiannakis [46]), improving road signage would be desirable, especially in high-risk locations such as ford crossings, small bridges, etc. Passive road signage is not expected to fully solve the problem, as people have been recorded to go around barricades [24], and ignore warnings from officials or warning gestures from bystanders [24]. Active warning systems (such as barricades with sounds and lights as used in railway crossings) would probably achieve higher percentages of compliance than passive ones [61]. Indications of water depth may also be useful, as drivers struggle to appreciate the real depth of water, especially in dark or difficult driving conditions. However, it has been suggested that such installations may not be effective in conveying how dangerous a certain water depth can be [34]. Awareness campaigns highlighting the danger of walking or driving in floodwaters in relation to their depth could be important for the public to effectively read depth gauges, if coupled with active road signage. More elaborate installations using specific thresholds or signs (lights, sounds, etc.) to communicate that the water is dangerously deep could be a more promising solution. Sharif et al. [34] suggested that improvements in this type of depth-gauging devices or installations to communicate the message of danger can enhance their role as a change of behavior motivator. Evidence of reduction of the percentage of individuals “crossing a river” intentionally has been very limited [37] and therefore, more research on the effectiveness of different installations should be carried out.

Large flood protection structures and infrastructure that keep the population and particularly the road users away from the rivers are capable of providing a better solution to the problem, especially in heavy-traffic, flood-prone road segments. However, developing such infrastructure across all potential flood-prone locations and river crossings is not practical due to extraordinary costs.

Apart from improving the infrastructure and its installations, educational and awareness campaigns should be carried out, targeting high-risk groups, including motorists, older individuals that reside in flood-prone areas (especially the ones residing in ground and below-ground floors), and professional or informal caregivers. These campaigns should be guided by findings in the field of behavioral sciences aiming to shape effective interventions. Providing information of the adverse outcomes of crossing a flooded river would be beneficial, especially when prompting people to weigh the risks involved against the benefits of safely reaching their destination [23]. Literature findings indicate that awareness campaigns highlighting the benefits of safe behavior in a positive emotional appeal can be an effective tactic [26]. However, further research on how a message or a campaign should be shaped to effectively influence the psychological and cognitive processes of decision making at the time of an emergency should be carried out. In addition, given that people’s behavior around floodwaters incorporates elements of perception [34], situational risk assessment, and rapid or even reactive decision making [26], it is important to survey perceptions in detail and with simulated or real-world experiments to understand how different perceptions may lead to different decisions [23].

Because of the inherent weaknesses or limitations of the approaches mentioned above, the use of multiple rather than a single measure is considered preferable, depending on the constraints or the particular characteristics of the place/country that the measures are applied.
The method developed in this study groups behaviors in categories based on the actions, decisions, and intentions of individuals in early stages of the studied incidents, when they had different options or courses of actions to follow. This choice was made because, at this early stage, the overall behavior of individuals was perceived as more critical than their actions once they were carried away by floodwaters or trapped in a basement. In other words, behavior and decision making would not make much difference nor would be very diverse once the victim was trapped in floodwaters. At this stage, most individuals would take protective actions. On the contrary, before this life-threatening emergency stage, individual decisions, such as crossing or not crossing a flooded road, can make an important difference, making behavior (as expressed by these choices) very influential.

5. Conclusions

The present study develops a system to categorize the behavior of flood victims around floodwaters, as reflected by their actions. This systematic classification provides a foundation for an improved understanding of the distinction between the different mechanisms and the prevalent behavioral types that lead to fatal incidents during floods. The proposed system has the potential to explore victims’ behaviors within the constraints imposed by the descriptive nature of the typical flood mortality datasets. In addition, the division of behaviors in different types allows the examination of statistical associations with different factors including victim demographics, the use of vehicles, and the types of surrounding environment.

These associations showed an ability to predict (at a rate close to 90%) whether a victim exhibited a risk-taking behavior, through a 3-factor statistical model. The victims’ age and gender, as well as the immediate surroundings and the surrounding environment (urban or rural), were all found to be statistically associated with the victim’s behavior.

The results show that risk-taking behavior is prevalent in fatal incidents, equaling approximately 3 out of 4 cases, with the most common motivation being attaining a destination. The high percentages of risk-taking behavior clearly show the importance of behavioral aspects in how dangerous situations develop during the flood for the victims. Consequently, due to the prevalence of these attitudes among flood victims, it is considered that changing the behavior of people around floodwaters or during flood events can be a key factor to reduce flood mortality. As infrastructure is gradually improving and technology allows for better extreme weather predictions and more accurate warnings, efforts should also be focusing on critical behavioral interventions. The study of empirical evidence derived from mortality datasets and the exploration of motivational pathways that lead to risk-taking decisions by behavioral sciences is a critical step to accomplish these interventions.

The findings provide an insight useful to shape and target educational and awareness programs or other public health policy interventions. High-risk individuals, such as motorists and the elderly or other important groups (e.g., caregivers) should be a priority when it comes to awareness campaigns. Nevertheless, the coupling of empirical findings regarding flood victims with a deep understanding of the psychological and cognitive factors that influence decisions would be beneficial for the effectiveness of future interventions.

By classifying behavior types into categories, the study contributes to setting the foundations for standardization of behavioral exploration of victims during floods that could be applicable anywhere in the world, so more data can be compared across different settings and countries.

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