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Duty or safety? Exploring emergency service personnel's perceptions of risk and decision-making when driving through floodwater

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ABSTRACT

Vehicle-related flood fatalities and rescues due to driving through floodwater are a significant emergency management issue for emergency services. To reduce fatalities, injuries, and costs associated with this risky driving behaviour it is essential to develop strategies to stop or reduce the incidence of people driving through floodwater. In Australia, people are told not to enter floodwater – on foot or in vehicles – with the phrase 'If it's flooded, forget it' widely used in official messaging. As first responders responsible for floods, storms and tsunamis, Australian State Emergency Service (SES) personnel are working in flood conditions regularly and are considered an occupationally 'at-risk' group for driving through floodwater. Although SES agencies across states and territories in Australia are independently led, they typically promote policies of not entering floodwater to their personnel. Such policies are important for meeting duty of care obligations to employees, for protection of assets (vehicles and equipment), and for upholding organisational reputation (leading by example). This study was undertaken to explore the behaviour of driving through floodwater by SES personnel. The study explored the characteristics of those who have and have not driven through floodwater, and then used detailed situations in which SES personnel entered floodwater in vehicles to analyse their perception of risks, the conditions and contexts in which they entered floodwater, and to identify what influenced their decision to enter.

Following an earlier systematic literature review, a detailed online questionnaire was developed and administered to SES personnel from a single agency. Data from 670 respondents indicated that 54.8% had driven through floodwater in the previous two years, and a number of differences in the profile of those who had/had not driven through floodwater were identified. Those more likely to have driven through floodwater included males, volunteer personnel with longer lengths of service, those doing more driving hours per week, those deployed to work in flood conditions, and those with current flood rescue qualifications. The location type, water depth, and water velocity were conditions that contributed more to perception of risk at the time personnel drove through the floodwater. Detailed information about an experience of entering floodwater was obtained from 201 respondents who had driven through floodwater in SES vehicles, and six factors relating to the decision to drive through floodwater were extracted. 'Organisational training and safety', 'External locus of control' and 'Absence of risk signals' were identified as having the greatest influence on risk perception leading to decisions to drive through floodwater. The findings of the study have a number of practical implications for the improvement of occupational safety management; such as upgrading risk assessments strategies, reviewing workplace health and safety policies, enhancing training, increasing skills and knowledge of emergency services personnel about floodwater hazard situations, and improving internal flood risk communication.

1. Introduction

People entering floodwater in vehicles is a leading cause of flood-related drowning deaths globally [1–7]. In Australia, driving through floodwater is a common flood experience for people [8]. Recent Australian flood fatality data showed that at least 96 deaths occurred in 74 incidents between 2001 and 2017 due to flood-related vehicle accidents with a mean of 1.3 fatalities per incident and the mean death toll across the study time period was 5.7 fatalities per year [9]. According to post-mortem reports, drowning was identified as the primary medical cause of death in 66% of the recorded fatalities (n = 96) and 24% occurred due to injury while drowning [9]. State Emergency Service (SES) agencies in Australia

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devote significant time and money to rescuing people who have intentionally driven through floodwater in vehicles each year. One research study [10] conducted following flash floods in the Hunter Valley (120 km north of Sydney) on 8–9th June 2007 reported that, of the 36 rescues in the SES dataset, 13 (36%) were rescuing people from vehicles. Information sourced from the NSW SES website to the end of September 2016 indicates that nearly 550 flood rescues have been performed by NSW SES in 2016 alone [11]. During the flooding of June 2016, NSW SES performed 300 flood rescues, approximately a third of which involved rescuing people from flooded vehicles [11]. It is a significant emergency management challenge for SES personnel to perform potentially life-threatening and costly rescue operations for vehicle-related incidents during floods each year, and for SES agencies to communicate the dangers to the public to reduce the incidence of this risky driving behaviour.

Generally, the nature of SES personnel's work in flood and storm contexts demands that they make quick and safe decisions under time pressure and changing conditions. This places them among the top of those professions who work in natural hazard-related emergency settings, in terms of balancing their own safety with their duty. Working in hazardous situations with vehicles in flood conditions engages these emergency workers in a potentially complex combination of risk scenarios. They must arrive quickly at the emergency scene, at any time of the day or night. Incidents may be located in remote and difficult to access areas (mountainous or hilly areas, bridge or river crossings with rapid, rising floodwater), with changing and sometimes extremely difficult weather conditions (heavy rain and wind), and with unknown road conditions (road grade, road pavement integrity, or road alignment under water). A recent study in Australia [12] explored the lived experience of emergency service workers who undertake flood rescues of those who have driven into floodwater. This interview-based study identified four challenges: involvement of untrained personnel; varying information provided by emergency telephone operators; behaviour of drivers complicating the rescue; and people sightseeing floods or flood rescues or ignoring closed roads providing rescuers with sources of distraction and frustration.

In general SES agencies rely on safety management practices and interventions to encourage their personnel to avoid floodwater risks, yet there is no evidence available to know whether personnel adhere to these influences or if they are obliged to follow these safety policies as part of their role. SES in the state of Victoria (VICSES) has recently developed operational doctrine to support personnel in assessing and managing the risk associated with encountering floodwater in VICSES vehicles [13]. In addition, in revising its values, VICSES members agreed to incorporate 'Safety Drives Our Decisions' to reflect the importance of safety to the organisation, and this was rated as one of the highest of their five organisational values [14]. Still it is important to acknowledge that because of the service they provide, the organisation may never be able to create a regulation to reduce risk to zero and stop its personnel from ever driving through floodwater. However, this issue needs to be addressed as a matter of priority, as it relates to occupational health and safety risks for this emergency service group. To reduce the costs of physical damage to vehicles and other assets, to protect personnel's lives, there is an urgent need to understand the real experiences of SES personnel who have encountered and driven through floodwater and the decisions that directed their actions. Thus, the aims of the current study are to explore SES personnel's experiences of driving through floodwater in SES vehicles; to see the differences between those who had driven through and who did not, to explore their perception of risks of a recalled incident of driving through floodwater, to identify what influenced their decision-making to drive through, and to test whether there is an association between their perceived level of risks and decision-making factors.

1.1. Vehicle-related flood fatality research

Consideration of flood fatality research literature is important for helping to understand the circumstances in cases where driving through floodwater has been deadly. It also enables us to compare the circumstances in which our SES personnel cohort had driven through floodwater.

International flood fatality research involving vehicles suggests that incorrect assessment of flood conditions [3,15] and underestimating risks [3,16,60] leads drivers to make inaccurate decisions which can lead to fatal incidents. Flood conditions are typically described in research using the following categories: floodwater characteristics (water flow and depth), roadway characteristics (location, road type, crossing type), vehicle characteristics (vehicle type and operation, e.g. four-wheel drive (4WD)) and environmental circumstances (weather, lighting). Floodwater characteristics such as depth and flow are primary influencers of vehicle (in)stability, and have been described in recent research [17]. Research on vehicle stability in floodwater describes a three-phase process; of floating, sinking and submersion [18]. Research has demonstrated that the floating phase may last only 30 to 120 s, followed by the sinking phase, which is typically completed within 2 to 4 min of contact with the water [18,19]. Research into the dynamics of vehicles in floodwater has found that in fast-flowing floodwater of 3 m per second or greater, it can take just 15 cm of floodwater for a small vehicle to become unstable, and only 30 cm for four-wheel drive (4WDs) vehicles [20]. Vehicles may enter floodwater upright, or roll due to rapid flow [20].

The risks associated with driving through floodwater may also be determined by the characteristics of the location [3,16] and roadway characteristics such as road structure type; roadway side barriers; road side topography; downstream depths adjacent to the roadway; signage; warning systems; lighting; road pavement; road alignment; road grade; speed restrictions; traffic volume, presence of road side markers and curb and guttering [21]. Vehicle characteristics like vehicle size, type, or operational drive control may also give drivers confidence in their ability which may minimise the sense of risk [22].

One recent study [9] rigorously explored the circumstances of recent vehicle-related deaths in Australia, to help understand the flood conditions associated with vehicle-related flood fatalities. This research reported that the shallowest water depth responsible for one fatal incident was only 20 cm. Almost two thirds of fatalities (63%) included reports of very fast flowing and rapidly rising floodwater, and most victims (87%) were attempting to cross creeks, low bridges or causeways. Much smaller proportions (4%) occurred at a ford or weir, or on a normal stretch of (flooded) road. Regarding the environmental conditions, the largest proportion of fatalities occurred in the evening and night when it was dark (50%) and in the incidents that occurred at night, all reported an absence of adequate street lighting.

1.2. Concepts from theories

To understand the behaviour and underlying decision-making processes of driving through floodwater by emergency services in occupational situations, the present study developed a conceptual framework based on psychological theories. To address the behavioural and cognitive thinking aspects, the study adopted concepts from two theories to help understand behaviour, which had not been applied previously in driving through floodwater research. These theories are the Recognition Primed Decision-Making Model (RPD) and the Extended Parallel Process Model (EPPM).

1.2.1. The Recognition Primed Decision-Making Model (RPD)

Naturalistic decision-making research has shown that experienced people under pressure in complex situations do not generally use the classical approach to decision-making [23]. Under these circumstances, people tend to operate in a manner depicted by the recognition-primed decision (RPD) model [61]. RPD model development evolved from field observations and interviews with fire fighters, neonatal intensive care nurses, surgeons, weather forecasters, military field commanders and pilots. Thus, the context for the research was situations that are circumstance-dependent and may be subject to rapid change which appears to be a good fit with emergency workers' situations in natural hazard events. As described by Klein et al. [[24]], the process involves a decision-maker noticing situation-generated cues, recognising patterns formed by the cues (based on experience), focussing on a potential solution or 'action script,' and imagining potential outcomes of action implementation. The latter involves experience again in the form of the decision-maker's mental model of the overall operations. If the imagined outcome is 'good enough,' then the action is implemented. In short, the RPD process highlights three simple steps: experiencing the situation, analysing the situation, and implementing the decision.

The current study utilised the RPD model approach to help conceptualise the decision-making process for emergency service personnel in flood situations. In these situations, they need to form a risk assessment based on synthesis of a number of contextual and conditional components.

1.2.2. The Extended Parallel Process Model (EPPM)

EPPM is one of the major theories within the domain of psychological research on health behaviour. Research using EPPM covers a large number of health-related topics such as drug abuse [25], but EPPM has also been used in vehicle-related behaviour, e.g. driver safety [26] and driver fatigue [27]. However, studies applying EPPM to natural hazards situations have not been identified to date. The EPPM posits that when presented with a risk message, individuals engage in the following outcomes via two appraisal processes: danger control process and fear control process [28]:

- Outcome I: Danger Control—People take protective action against the threat.
- Outcome II: Fear Control—People in denial about threat react against it.
- Outcome III: Lesser Amount of Danger Control—People take some protective action, but are not motivated to do much.
- Outcome IV: No Response—People do not consider the threat to be real or relevant to them, or are often not even aware of the threat.

1.2.3. Psychological research applied to driving though floodwaters

Previous research has provided a body of emerging evidence of the psychological factors that influence individuals' decisions to drive through floodwater [29,30,62] including past experience, attitudes, social pressure, self-efficacy beliefs, and risk perceptions. Regarding the latter, the severity of the risk has been shown to have an effect on reducing drivers' willingness to enter floodwater [30].

Building on this previous research, Hamilton and colleagues have recently conducted a series of studies using qualitative, mixed method, and experimental designs to better understand the influences on individuals' beliefs and intentions to drive, and avoid driving, through floodwater [31–34]. It is important to understand the differences in beliefs guiding behavioural alternatives (i.e. intentionally driving through, or avoiding driving through, floodwater) as there is research to suggest that performing and not performing a given behaviour are not conceptual opposites. Different motivational pathways may operate in guiding individuals' decisions to engage (or avoid engaging) in an action or behaviour [35]. Findings from two qualitative studies [32,34] investigating the beliefs influencing drivers' decisions to drive and avoid driving through floodwaters are presented below.

In a study exploring driver decisions through the lived experience, Hamilton, Peden, Keech & Hagger [32] identified four overarching themes that emerged from drivers' descriptions of factors that influenced their decision to drive into floodwaters. These were past experience, individual factors, the social and environmental context, and self-efficacy judgements. In a second study investigating the psychological influences underpinning decisions to avoid driving through floodwater, Hamilton et al. [34] identified three overarching themes. Based on the Theory of Planned Behaviour (TPB) belief-based framework, drivers' descriptions of factors that influenced their decision to avoid driving through floodwaters were linked to their behavioural beliefs, e.g. safety first and foremost, their normative beliefs, e.g. think of the rescuers, and their control beliefs, e.g. that the destination wasn't that important.

1.3. Conceptual framework for the current study

Supported by the previous research findings and theories just outlined, the present study uses the following conceptual framework as a model for the decision-making process of driving through floodwater for this emergency service occupational group (Fig. 1).

Similar to the RPD process, the model (Fig. 1) proposes the steps of decision-making including: experiencing the situation, analysing the situation, mental simulation of action, and implementing the decision into behaviour. Supported by findings from previous review papers [1,36] the model proposes risk perception as the core aspect of the decision-making process to take the decision to drive through floodwater.

The model features perception of risk determined by two components: risk assessment factors and influences on decision-making. Risk assessment informs risk perception through evaluating the physical characteristics of the context and the environment, and a number of socio-cognitive factors influence decision-making to guide risk processing and inform risk perception. After initial mental simulation of the action, the final steps of the decision-making process include two processes from the EPPM model: protection motivation (danger control process), and defensive motivation (fear control). The outcome of these two processes leads into the final decision being formed, which is then implemented into behaviour.

2. Methods

2.1. Study design and procedure

The study was administered using the online platform Survey Monkey. The Macquarie University Human Research Ethics Committee granted ethical approval for this study on 12th September 2017 (Reference number: 5201700133). Participation was voluntary, with all participants ensured confidentiality and anonymity of responses prior to commencing. Participants were recruited via an email from the SES Deputy Commissioner endorsing the study, which was sent to all personnel. This email was distributed when the study opened on the 16th July 2018 and a reminder email was sent one week prior to the study closing date, which was the 13th of August 2018.

2.2. Participants

A non-random convenience sample of SES personnel ($N = 670$) was recruited via email. The average age range of the respondents was 45–54 years. The majority of respondents (77.1%, $n = 517$) were over 35 years of age, with just over two thirds being male (67.9%, $n = 455$). Volunteer personnel made up the majority of the sample (89.1%, $n = 597$), and most (80.6%, $n = 540$) had held a full driving licence for >10 years. The majority (91.5%, $n = 184$,) had experience of deployment to local flood events. Almost three quarters (73.1%, $n = 490$) had received flood rescue training to a minimal level of qualification. Participants had received a range of other relevant training experience with over three quarters (78.1%, $n = 157$) receiving general operational driver training and just under half (48.8%, $n = 98$) receiving four-wheel drive vehicle training.

2.3. Measures

The behaviour of interest in this study is the act of driving through floodwater by SES personnel driving an SES vehicle, i.e. the person in command of the vehicle. The term floodwater was defined based on a definition provided by the Australian Government Department of Geoscience Australia [63]: "an overflowing of water onto land that is normally dry and is not limited to roads". This study employed a more driving- and road-specific definition that was agreed in consultation with SES project officers before the study so that it would be relevant to personnel.

Participants received the definition of floodwater in the following way. "Currently, there is no clear definition of floodwater. For the purposes of this survey, we will define floodwater as an environment with:

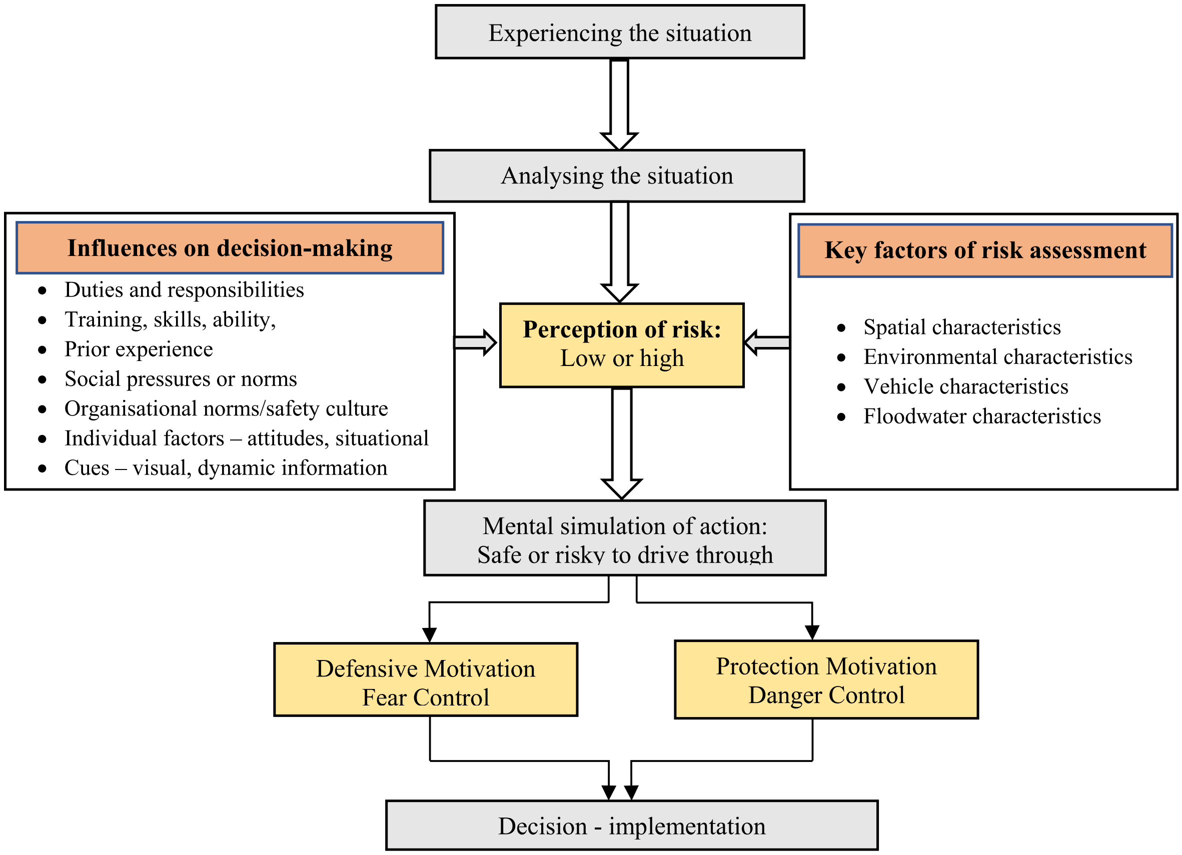

Fig. 1. Conceptual decision-making model of driving through floodwater for emergency service personnel.

1. Water across the road surface.
2. Little to no visibility of the road surface markings under the water (i.e., uncertain of road quality/integrity and possibly depth).
3. Water on normally dry land – flowing or still

Based on the floodwater definition above…"

After this definition was presented, participants were asked three questions; How many times they had driven through floodwater in the last two years in an SES vehicle - as a driver, how many times they had been driven through floodwater in an SES vehicle - as a passenger, and how many times they had driven through floodwater in their own private vehicles - as a driver (responses were Never, 1–2 times, 3–6 times, >6 times). Then the respondents were asked "Can you recall an event in which you drove (or were driven) through floodwater in an SES vehicle - ideally the most memorable occasion in the last few years?". The objective was to explore their experiences of entering floodwater in SES vehicles.

2.3.1. Exploratory variables

In addition to a range of demographic variables, the questionnaire included the following contextual variables, linked to the specific incident of driving through floodwater that they had recalled, to measure risk assessment factors, decision-making influences, and level of perceived risk associated with the recalled incident of driving through floodwater.

2.3.1.1. Key factors of risk assessment. To measure the key factors of risk assessment the following variable categories were included in this study:

2.3.1.2. Spatial characteristics. Previous research on flood fatalities in Australia has focused on geographical locations [8,10,37–39], road characteristics [21], residential location of drowning victim, and the remoteness of the incidents [39] as important factors for flood fatalities. The present study included location type (urban, suburban, regional, rural and remote); road type (major, minor/suburban, sealed, unsealed, causeway) and type of crossing (a low-water crossing, bridge, or causeway, a ford or weir, a normal stretch of road) as spatial variables to explore how these variables influenced the decisions taken.

2.3.1.3. Environmental characteristics. Environmental components, such as time of day, lighting conditions, and weather have been found to influence both the cognitive process of floodwater hazard identification on roads and decision-making [16]. It has been hypothesised that drivers at night/in dark conditions are either not able to see flooded roads and possibly enter floodwater by accident [5], or they are not able to assess the depth and velocity of water due to poor visibility [16]. To identify the environmental variables in this study, time of day (lighting conditions (daylight, dark daylight, dawn/dusk, night with streetlight, night with no streetlight)) and weather conditions (clear, overcast, light rain, steady rain, heavy rain) were assessed.

2.3.1.4. Floodwater characteristics during incident. Previous studies have found that water characteristics such as water depth, water flow, and presence of debris or mud have significant influence on driver's decision making to enter floodwater. Floodwaters can submerge vehicles or sweep them away. Motorists may enter floodwaters unexpectedly [15] or find themselves in circumstances where floodwaters rise around their vehicle [40]. In the present study, the variable water depth at the time of the driving incident was measured using a 6-point categorical scale grouped as A. "Less than 15 cm", B. "15 cm to 30 cm", C. "30 cm to 45 cm", D. "45 cm to 60 cm", E. "60 cm to 95 cm", and F. "Greater than 95 cm". To reduce inconsistency in their estimations of the depth of each category level, participants were provided with an image as a reference with the instruction that 'water heights are shown against a sedan - to help estimate the depth' (Fig. 2). The present study also included water flow as a variable to understand the

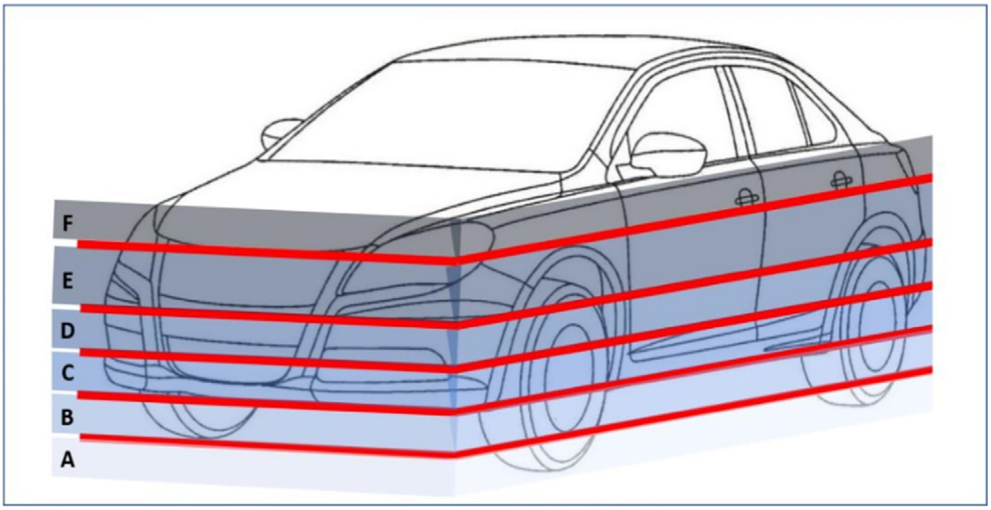

Fig. 2. Image provided in the survey as a reference for depth of water driven through.

characteristics of water in drivers' decision-making (still, slow, medium/moderate, rapid/swift flow).

2.3.1.5. Vehicle characteristics. Research in Australia which explored the types of vehicles driven through floodwater, found that they varied considerably in size and type [22]. In a study [39], rates of non-aquatic transport flood related drownings per 100,000 registered vehicles were calculated using Australian vehicle registration data. The vehicle types used in that study [39] were - passenger vehicles (car, four-wheel drives (4WD)), light commercial vehicles (utilities), rigid trucks (heavy vehicles, machinery) and motorcycles (motorbikes, All Terrain Vehicles (ATVs)). For emergency response in operational situations, SES is well equipped with vehicles suited to their work. However, SES personnel also drive work passenger vehicles, as well as their own private vehicles in the context of their work, e.g. in day to day situations, travelling to/from duty and deployments. In consultation with SES, the study included vehicle types representative of all SES vehicles, e.g. medium/heavy truck, light truck/dual cab, passenger vehicle, and other types of SES vehicles (SUV, Ute etc.). Vehicle operation (all-wheel drive, four-wheel drive, and two-wheel drive) was also included separately to capture the potential influence of the ability of the vehicle (as well as size) on the driver's willingness to drive through floodwater [29].

2.3.1.6. Influences on decision-making. The study used a list of 18 potential influences to explore socio-cognitive and other potential influences on drivers' decision-making processes. These included environmental cues, individual attitudes and situational contexts (e.g. journey characteristics), efficacy responses, social influences, past experience, familiarity with road and place, organisational safety attitude and professional skills and knowledge. The items (see Table 1) were based on the findings of previous research [1,31]. Respondents were asked the extent to which these 18 aspects influenced their decision to drive through the floodwater on this occasion. A 7-point Likert scale of response choices was used, ranging from (1) not at all to (7) a great deal.

2.3.1.7. Perception of risk. A single item was used to assess the level of perceived risk when the driver drove through the floodwater. Respondents were asked "How risky do you think it was to drive through floodwater on this occasion?" A slider scale was used to indicate the level of perceived risk, with endpoints labelled 'not at all risky' to 'extremely risky'. The slider registered values from 0 (not at all) to 100 (extremely).

2.3.1.8. Demographic information. Demographic and background information collected in this study included:

- Age, in categories, ranging from 18 to 75 or older
- Gender, in categories, male, female, rather not say
- Years holding full driving licence, with response categories ranging from "0 (still Provisional/Learner status)" to "More than 10 years"
- Average number of hours driving each week, with categories ranging from "less than 2 hours", to "15 or more hours"
- Years' experience as a paid, or unpaid SES member, with responses ranging from "Less than one year" to "More than 20 years"
- Current qualifications in Flood Rescue, with responses ranging from "Yes, Flood Rescue Awareness" to "No, I have no Flood Rescue Qualifications"
- The respondents were asked "Do you get deployed to work in flood/storm conditions?" with responses options "Yes" or "No".
- Frequency of driving SES vehicles, with responses ranging from "Rarely" to "All the time"

2.4. Approach to analysis

All data analysis was conducted using Statistical Package for Social Sciences (SPSS version 25). Both non-parametric (chi-square, k-means cluster analyses and principal component analyses for factor analyses) and

Table 1
Items used in this study to measure the influences on the decision to drive through floodwater.

Item no.	Items used
1	The journey was urgent
2	No alternative route
3	Impractical alternative route (time/distance)
4	Lack of signage/indicators to show depth or danger
5	Behaviour of others, e.g. others driving through without problems
6	Careful consideration of the situation
7	Knowing the road well
8	Driving through floodwater previously without problem
9	Professional SES training/knowledge
10	Reassurance or encouragement from others in the vehicle
11	Belief in my own physical ability to drive through
12	Close proximity to destination/operational situation
13	Gut-feeling that it would be all right
14	Being directed to drive through the water by other emergency services/council
15	SES's attitude towards safety
16	Excitement - it being fun to do
17	Organisational pressure to complete my duty
18	My personal desire to complete my duty

parametric (correlations and linear regressions) statistical tests were used in conducting different stages of analyses in this study. Data analysis was undertaken in a number of phases; first with the full sample ($n = 670$) including both those who had driven into floodwater and those who had not, then with the subsample who had driven through floodwater and provided detailed information about a specific incident when they drove through floodwater in a work context ($n = 201$). This progressive approach to analysis was used to explore the following research questions:

Phase 1: Chi square and post hoc tests

For the whole sample:

- Are there any differences in terms of demographic variables between those who have, and have not, driven through floodwater in the last two years?

Phase 2: Descriptive statistics, frequency and percentage distribution

For those who had driven through floodwater in the last two years:

- What are the contexts and conditions in which SES personnel have driven through floodwater?
- What are the key factors that influenced risk perception when SES personnel drove through floodwater?

Phase 3: K-means cluster analyses, chi square test and multiple regression

In relation to a specific incident of driving through floodwater

- What was the level of risk perceived at the time of the incident?
- What are the relationships between the expected risk factors and risk perception of the incident?
- Which risk factors contributed more to risk perception when they drove through floodwater?

Phase 4: Exploratory factor analysis - Principal component analysis

- What are the key factors influencing decision-making that are associated with driving through floodwater?

Phase 5: Correlation and Hierarchical multiple regression

- Is there any association between risk perception and the key decision-making factors that are associated with driving through floodwater?
- Which decision-making factors predict risk perception in situations that led to driving through floodwater?

3. Results and discussion

3.1. Phase 1. Exploring demographic differences between those who have, and have not, driven through floodwater

Overall, in the sample of 670 SES personnel, 54.8% ($n = 367$) had driven through floodwater as a driver in the last two years, compared to 45.2% ($n = 303$) who reported not having driven through.

Using a chi square analysis, significant relationships were revealed between the decision to drive through floodwaters in the last two years and participant demographics. These included: age; gender; years of holding a full licence; length of service with the SES; driving hours per week; flood rescue qualifications; frequency of driving an SES work vehicle; and deployment to work in floodwater conditions (see Table 2). Post hoc analysis of the multilevel variables within the chi square was undertaken. Fisher's exact approach and odds ratio analysis were then used to determine what level of participant demographics were contributing to the observed variance.

Analysis by age, found that those over 55 years of age were least likely to have driven through floodwater. Compared to this group, those aged 18 to 34, and those aged 35–55 were significantly more likely to have driven through (OR 2.07 and 1.44, respectively), $\chi2$ (2, $N = 666$) = 9.747, $p > .0076$. A two-way chi square revealed a significant relationship between gender and driving through floodwater, with males more likely to have driven through floodwaters in the last two years (OR 2.03).

Most participants had held a full driving licence for 10 years or more (82%). This group was more likely to have driven through floodwater in the last two years, compared to those who had held their driving licence for less than ten years (OR 1.79). The amount of time an individual spent driving each week was found to relate to whether they had driven through floodwaters in the last two years. Generally, more time spent driving on average each week related to an increasingly greater likelihood of having driven through floodwater, e.g. those who drove >15 h per week on average were 5.6 times more likely to drive through floodwaters than individuals who drove <2 h per week, $\chi2$ (3, $N = 146$) = 14.75, $p > .002$.

Increasing length of service, for volunteer personnel, was associated a lower likelihood of having driven through floodwater in the last two years. Generally, those with over ten years of service were least likely to drive through floodwaters, with individuals with 5–10 years' service (1.37 times more likely) and those with <5 years' experience (1.75 times) more likely to have driven through floodwaters in the last two years.

Two-way chi square analysis revealed significant differences in the increased likelihood of having driven through floodwater in the last two years for those who had current flood rescue qualifications compared to those without flood rescue qualifications (OR 1.94), and those who get deployed to work in floodwaters (OR 1.81) compared to those who don't get deployed.

Post hoc analysis of frequency of driving SES vehicles found that individuals who rarely drove an SES vehicle were the least likely to have driven through floodwaters in the last two years $\chi2$ (3, $N = 338$) = 21.752, $p > .000$, compared to individuals that drove an SES vehicle all the time (OR 1.28), those who drove an SES vehicle often (OR 2.56) and, those who drove an SES vehicle occasionally (OR 2.12).

This phase of analysis revealed that even though personnel are encouraged by the organisation not to drive through floodwater at work, the proportion of participants who had driven through in the last two years was high (54%). Interestingly, in this occupational sample male personnel were found to be significantly more likely to drive through floodwater than females. This supports findings in the literature that males are more likely to engage in driving through floodwater ([3,4,7,16,22,29,38,39,41]; Drobot et al., 2007).

Findings regarding age in this study indicate there might be differences in driving through floodwater between public and SES personnel. A recent study of self-reported flood-related behaviour of river users in Australia [42] reported that those aged 75+ years (42.9%) and 65–74 years old (40.7%) were the highest proportion of respondents who had driven through floodwaters; whereas in the present study younger male SES personnel aged 18–34 and 35–55 years were significantly more likely to have driven through floodwater.

The results regarding length of driving experience and flood deployment indicated that those who had been driving longer and those who get deployed to work in floods and storms were more likely to have driven through floodwater. These former findings suggest that experience, and possibly confidence, play a part in driving through floodwater. Obviously, those who are deployed to work in flood conditions are likely to have been exposed more to floodwater on the road in the last two years. Therefore, a combination of confidence and familiarity with driving in flood conditions, as well as increased exposure/potential to drive through floodwater may be having an influence. Analysis found that SES personnel who have current flood rescue qualifications are also more likely to have experience of driving through floodwater in the last two years. Again, there is potential that such individuals will have been sent to perform flood rescues in flood conditions and therefore been exposed to floodwater on the road when travelling. However, it is also more likely that they will have received training more recently and have been educated about the risks involved with floodwater.

Table 2
Frequencies, percentages, and adjusted standardised residuals (ASR) for driving through floodwaters in the last two years.

Variables	Had driven through floodwater once or more in the last two years								Total	χ^2 (*p* value)
	No				Yes					
	f	%	f_e	ASR[a]	*f*	%	f_e	ASR[a]		
Gender										
Male	179	26.7	205.8	−4.5	276	41.2	249.2	4.5	455	19.812, p = .001
Female	124	18.5	97.2	4.5	91	13.6	117.8	−4.5	215	
Age										
18 to 34	52	34.8	67.3	−2.8	97	65.1	81.6	2.8	149	12.575, p = .002
35 to 54	111	43.5	115.2	−0.6	144	56.4	139.7	0.6	255	
55 and above	138	52.6	118.4	3.1	124	47.3	143.5	−3.1	262	
Years holding full driving licence										
<10 years	39	5.8	52.5	−2.8	79	11.8	65.5	2.8	118	7.669, p = .006
More than 10 years	254	37.9	240.5	2.8	286	42.7	299.5	−2.8	540	
Driving hours per week										
Less than 2 h	37	5.5	23.3	4.0	15	2.2	28.7	−4.0	52	27.572, p = .001
2–7 h	132	19.7	122.7	1.5	142	21.2	151.3	−1.5	274	
8–14 h	81	12.1	83.7	−0.5	106	15.8	103.3	0.5	187	
15 h or more	45	6.7	65.4	−3.8	101	15.1	80.6	3.8	146	
Length of service (paid personnel)										
<5 years	31	4.6	29.0	0.7	32	4.8	34.0	−0.7	63	0.601, p = .740
5–10 years	11	1.6	12.4	−0.6	16	2.4	14.6	0.6	27	
More than 10 years	11	1.6	11.5	−0.2	14	2.1	13.5	0.2	25	
Length of service (volunteer personnel)										
<5 years	130	19.4	112.8	2.9	129	19.3	146.2	−2.9	259	10.005, p = .007
5–10 years	52	7.8	52.3	−0.1	68	10.1	67.7	0.1	120	
More than 10 years	78	11.6	94.9	−2.9	140	20.9	123.1	2.9	218	
Current flood rescue qualifications										
Yes	196	29.3	216.1	−3.7	294	43.9	273.9	3.7	490	13.412, p = .001
No, or not current	92	13.7	71.9	3.7	71	10.6	91.1	−3.7	163	
Deployed to work in flood conditions										
Yes	212	31.6	229.2	−3.2	298	44.5	280.8	3.2	510	10.206, p = .001
No	85	12.7	67.8	3.2	66	9.9	83.2	−3.2	151	
Frequency of driving SES work vehicles										
Rarely	119	17.8	92.0	4.7	93	13.9	120.0	−4.7	212	23.715, p = .001
Occasionally	78	11.6	89.8	−2.0	129	19.3	117.2	2.0	207	
Often	54	8.1	70.3	−3.0	108	16.1	91.7	3.0	162	
All the time	8	1.2	6.9	0.5	8	1.2	9.1	−0.5	16	

[a] The adjusted standardised residual is the observed frequency—expected frequency/estimated standard error.

Training might also increase confidence, leading to personnel minimising the risks of driving through floodwater on roads.

3.2. Phase 2: Exploring the conditions in which SES personnel drove through floodwater

To explore the conditions and contexts of the floodwater when they drove through it, participants were asked to recall their most recent or memorable experience of entering floodwater with vehicles in work conditions, ideally in the last few years. A total of 201 participants completed this detailed section. Table 4 summarises the various characteristics and conditions in which participants reported driving through floodwater.

Regarding spatial and environmental characteristics, around half of these incidents (49.3%, n = 99) took place in rural and remote areas, and a similar proportion of incidents (54.2%, n = 109) occurred on minor or residential road. Interestingly, a majority drove through the floodwater on a normal stretch of road (78.1%, n = 157). A noted earlier, recent fatality data indicated that a large majority of fatalities (87%) took place when vehicles were driven across creeks, bridges or causeways [9], suggesting that most of the incidents described by participants are likely to have not been life threatening in terms of this specific aspect.

Although around two thirds of incidents occurred in daylight (64.2%, n = 129), just under a quarter took place at night (23.4%, n = 47) and 22 of these incidents (10.9%) occurred in locations without street lighting. In these latter situations, it is likely that accurate assessment of the floodwater conditions would have been challenging. It was raining in 51.7% of incidents (n = 104), which varied from light rain to heavy rain.

In terms of the floodwater characteristics of water depth and water flow, both key factors known to affect vehicle stability, around three quarters of incidents occurred in water that was estimated to be >15 cm deep (77.1%, n = 155). This is above the level at which some vehicles are at a risk of becoming unstable [17] and above a level that is generally communicated to the public to be particularly unsafe to enter through the "15 to float" campaign Victoria SES 2017 [43]. The results regarding velocity of water indicated that although SES personnel took risks entering deeper water, they mostly drove through water with low velocity (slow or still water) (92.0%, n = 185). A minority of incidents (16.9%, n = 34) took place in water deeper than 45 cm, and 7.9% (n = 16) took place in water with moderate or rapid flow. Clearly, these less frequent but seemingly more risky incidents need to be investigated more closely.

In terms of vehicle characteristics, dual cabs/light truck vehicles were most frequently being driven (44.2%, n = 89) and in the majority of incidents vehicles were four-wheel drive (67.7%, n = 136) indicating that vehicles typically larger and heavier than passenger vehicles were mostly being driven when floodwater was entered.

Activities being undertaken at the time of entering floodwater were, most commonly, emergency response 'under lights and sirens' (i.e. urgent response) (n = 101, 51%) and emergency response 'not under lights and sirens' 31% (n = 61). Other responses included undertaking a private journey (21%; n = 42), travelling to/from an SES unit (17%; n = 35), and routine work (11%, $n = 23$). This clearly supports expectations that occupational exposure and the nature of emergency service work is a risk factor for this group. In a third of incidents (32.8%, $n = 66$) visible signage indicating flooded road conditions, such as road closure, depth indicators and flood warnings signage was present, but was ignored. In just under two thirds of reported incidents (64.2%, $n = 129$) there was no visible signage on the road when they drove through. In 2015, Austroads, the peak body for road management in Australia, stated that the vast majority of the approximate 20,000 floodways in Australia and New Zealand were not constructed in accordance with required design and hydraulic standards, and lacked appropriate signage. They also reported that depth gauges could be misinterpreted, posing a risk to road users in flood situations [44].

3.3. Phase 3: Relationship between key risk assessment factors and risk perception

The conceptual decision-making model of the present study (Fig. 1) indicated that risk assessment factors (spatial, environmental, floodwater, vehicle characteristics) existing at the time of the incident contribute to construct the individual's risk perception. This part of the analysis sought to identify the relationship between risk assessment factors and level of risk perception, and verify the degree of contribution of those risk factors to risk perception.

To investigate the level of perceived risk associated with the reported incidents of driving through floodwater a K-means cluster analysis, using the z-scores, was performed on the variable 'perceived risk'. This approach was used to divide the sample into two risk typologies; those who perceived the incident to be higher (High) risk, and those who perceived the incident to be lower (Low) risk. This K-means cluster analysis is summarised in Table 3.

The first cluster, labelled 'low risk' comprised 83.6% ($n = 168$) participants, and the second cluster labelled 'high risk' comprised 16.4% (n = 33). Next chi square analyses were conducted to investigate differences between these two clusters in terms of incident-specific contextual variables.

The results from chi square analysis presented in Table 4 revealed that within the lower perceived risk group the majority of reported incidents occurred in urban/suburban and regional areas (55.9.%; $n = 94$), whereas within the higher perceived risk group the majority of reported incidents occurred in rural/remote areas (75.7%; $n = 26$) ($\chi 2 = 11.209$, $p < .005$). In terms of water depth, 93.9% of reported incidents ($n = 31$) in the high perceived risk group occurred when the water height was >15 cm compared to 73.8% ($n = 124$) for the low perceived risk group ($\chi 2 = 6.33$, $p < .01$).

The most highly statistically significant result was found for water velocity ($\chi 2 = 20.099$, $p < .001$). Only 4.1% ($n = 7$) of reported incidents perceived to be low risk occurred with high water velocity, compared to 27.2% ($n = 9$) of those reported to be high risk. Differences were not found to be statistically significant for other variables like road type, crossing type, lighting conditions, weather conditions and vehicle operation type.

Overall, results suggest that risk perception was most differentiated by the three key features: location, water depth and water flow. Based on these results multiple regression analysis was conducted to see which category of these three variables contributed more to predict risk perception (Table 5).

Multiple regression analysis using dummy coding for categorical variables (location, water depth and water velocity) revealed that perception of risk was significantly associated with these three variables. The results indicated that those driving in rural/remote areas, or where water depth was >15 cm, and in situations with high water velocity were more likely to perceive the risk of their driving through floodwater incident as high. Conversely, they were more likely to perceive the risk of driving through floodwater as 'low risk' when the location was urban/suburban, or water depth was <15 cm, or water velocity was low (slow/still).

Examining how emergency services personnel perceived the risks of driving through floodwater and investigating the relationships between the key risk factors and their link to risk perception is helpful for a better understanding of the risk assessment process when entering floodwater. From the overall result of this phase of the analysis, it can be concluded that these three characteristics – water depth, water flow, and location, played an important role in the risk assessment of SES personnel. Although how these three features work together is not identified in this study, it is nonetheless evident that these key features contribute significantly to risk perception, and could usefully be exploited in engagement and communication around the risks of driving in floodwater.

3.4. Phase 4: Factors influencing decision-making

In our conceptual model (Fig. 1), socio-cognitive influences form a large part of the risk processing component of the model. These affect the 'situational analysis' along with the key factors of risk assessment to inform risk perception.

To identify the key influences on decision-making during the incident of driving through floodwater in this study, exploratory factor analysis was conducted on the set of 18 influencing items used in the questionnaire, using principal components analysis (PCA) as the method of factor extraction. To decide what factors to retain, the study used the scree plot. Initially an oblique rotation was used to assess factor correlation and later varimax was used as a final rotation. Individual loadings of 0.40 or greater were used in the factor designation. Extracted factors were examined and named based on an analysis of the items loading on each factor. Cronbach alpha (α) was used to estimate the internal consistency of the items constituting a factor. The Kaiser–Meyer–Olkin test and Bartlett test of Sphericity were undertaken. This analysis indicated that the Kaiser–Meyer–Olkin coefficient for this dataset was 0.735 and the Bartlett test of Sphericity was statistically significant ($\chi 2 = 742.809$, df = 153, $P < .0001$) indicating that properties of the correlation matrix justified factor analysis being carried out. Table 6 shows the factor loading score for each item.

Varimax factor rotation identified six latent factors. Extraction of factors was based both upon Kaiser's criterion for Eigenvalues of equal to or greater than unity and use of a Scree plot. The six factors identified accounted for 60.0% of the total variance within the data (see Table 7). One of the items ("close proximity to destination") was removed, as its highest factor loading was below 0.30. In addition, the item had low communality scores, indicating that the extracted factors explain little of these items' variance. A sixth factor contained a single item ("lack of signage/indicators to show depth or danger"); this factor was retained, as the item had a high factor loading and it was uncorrelated with other variables.

Significant factor loadings were used to identify and interpret themes, then each factor was labelled with a factor name that the research team felt best represented the overarching theme. The first factor, labelled "Organisational training and safety" describes the professional experiences, training and knowledge participants felt they had to negotiate the risks of driving in flood conditions. This factor encompasses three items covering issues such as professional SES training/knowledge; SES's attitude towards safety and careful consideration of the situation. This factor accounted for 20.86% of the total variance and had a total eigenvalue of 3.75.

The second factor labelled "External locus of control" refers to how much people attribute the decision to drive through floodwater to external

Table 3
Cluster centroids for the perceived level of risk score.

Perceived level of risk score	Cluster 1	Cluster 2	F	df	p	Distances between final cluster centres
	Low risk	High risk				
Z score	−0.36770	1.8719	446.601**	199	<.001	2.240
Number of cases	168	33				

** $p < 0.01$.

Table 4
Frequencies, percentages, and adjusted standardised residuals (ASR) for the contexts and conditions in which SES personnel drove through floodwater and the level of perceived risk associated with these incidents.

Contextual variables	Low perceived risk				High perceived risk				Total	χ^2
	f	%	f_e	ASR	f	%	f_e	ASR		
Location type										
Urban/suburban	63	37.5	57.7	2.1	6	18.2	11.3	−2.1	69	11.209, p = .004**
Regional	31	18.4	27.6	1.8	2	6.06	5.4	−1.8	33	
Rural/remote	74	44.0	82.7	−3.3	25	75.7	16.3	3.3	99	
Road type										
Highway/major	45	26.7	47.6	−1.1	12	36.3	9.4	1.1	57	3.552, p = .169
Minor/residential	96	57.1	91.1	1.9	13	39.	17.9	−1.9	109	
Unsealed/track	27	16.0	29.3	−1.1	8	24.2	5.7	1.1	35	
Crossing type										
Normal stretch of road	133	79.1	131.2	0.8	24	72.7	25.8	−0.8	157	1.389, p = .499
A ford or weir	8	4.7	7.5	0.4	1	3.03	1.5	−0.4	9	
Bridge or causeway	27	16.0	29.3	−1.1	8	24.2	5.7	1.1	35	
Depth of water										
Less than 15 cm	44	26.1	38.4	2.5	2	6.06	7.6	−2.5	46	6.33, p = .012
>15 cm	124	73.8	129.6	−2.5	31	93.9	25.4	2.5	155	
Water velocity										
Low	161	95.8	154.6	4.5	24	72.7	30.4	−4.5	185	20.099, p < .001***
High	7	4.1	13.4	−4.5	9	27.2	2.6	4.5	16	
Lighting conditions										
Day light	113	67.2	107.8	2.1	16	48.4	21.2	−2.1	129	5.847, p = .054
Dusk/dawn	21	12.5	20.9	0.1	4	12.1	4.1	−0.1	25	
Night - dark	34	0.59	39.3	−2.4	13	39.3	7.7	2.4	47	
Weather conditions										
Rain	84	50.0	86.9	−1.1	20	60.6	15.9	1.1	104	1.243, p = .265
No rain	84	50.0	81.1	1.1	13	39.9	17.1	−1.1	97	
Vehicles operation type										
4WD	116	69.0	113.7	0.9	20	60.6	22.3	−0.9	136	0.898, p = .343
AWD/2WD	53	31.5	54.3	−0.9	12	36.3	10.7	0.9	65	

[a] The adjusted standardised residual is the observed frequency—expected frequency/estimated standard error.
* p <0.05. ** p < 0.01.
*** p < .001.

factors. People with a high internal locus of control ('internals') tend to believe that most things that happen are their own fault, regardless of objective cause. On the other hand, those with a high external locus of control ('externals') tend not to accept blame for anything, preferring instead to believe in environmental reasons, even if they have clearly instigated an incident. In the present research, three items that generally covered external influences loaded onto this factor. The items are organisational pressure to complete my duty, my personal desire to complete my duty, and being directed to drive through the water by other emergency services/council. Although the second item contained an element of internal motivation ('my personal desire') it was felt that it was the external act of 'duty' or service to others that was being triggered in the context of these other externally-driven items for this factor. This factor accounted for 11.03% of the total variance and had a total eigenvalue of 1.98.

Table 5
Summary of multiple regression analysis for location, water depth and water velocity on perceived level of risk.

Factors	β	SE B	R	R^2	df	F
Location			0.238	0.057	198	5.94**
Rural/remote	0.231*	3.3				
Urban/suburban	−0.010	3.5				
Depth of water			0.189	0.036	199	7.37**
Less than 15 cm	0.189**	2.8				
Water velocity			0.342	0.117	199	26.32***
High	0.342***	4.1				

* p < 0.05.
** p <0.01.
*** p < 0.001.

The third factor, labelled "Self-efficacy judgement", grouped together items that appeared to describe a combination of self-efficacy and optimism. Self-efficacy is the belief in one's own ability to do something [45]. Self-efficacy refers here to the belief of the driver that the behaviour – "driving through floodwater" can be executed successfully. This encompasses four items covering issues such as gut feeling that it would be all right, knowing the road well, driving through floodwater previously without problem, and belief in my own physical ability to drive through. This factor accounted for 8.46% of the total variance and had a total eigenvalue of 1.52.

The fourth factor labelled as "Journey characteristics" comprises three items and covers issues such as no alternative route, urgency to continue journey and impractical alternatives to change journey plan based on time and distance. This factor accounted for 7.74% of the variance and had a total eigenvalue of 1.39.

The fifth factor labelled "Social influences" includes items that describe the perceived social pressures or encouragements from others to perform the behaviour. This factor comprises three items covering the behaviour of others, e.g. others driving through without problems, reassurance or encouragement from others in the vehicle, and the behaviour being exciting 'fun to do'. This factor accounted for 6.28% of the total variance and had a total eigenvalue of 1.13.

The final, sixth, factor labelled "Absence of risk signals" related to the absence of warnings, signage and indicators that signal danger. This factor included only one item and accounted for 5.64% of the variance and had an Eigenvalue of 1.01.

Previous research findings supported the relevance of these themes as key influences in driving and health behaviour-related contexts. Rogers [46] states that "There is a fundamental link between training, experience

Table 6
Factor loadings for exploratory factor analysis with varimax rotation of influences on decision-making.

Items	Factors					
	1	2	3	4	5	6
The journey was urgent	0.312	0.203	−0.004	**0.661**	−0.310	0.079
No alternative route	0.215	0.105	0.166	**0.661**	−0.065	0.074
Impractical alternative route (time/distance)	−0.154	−0.028	0.134	**0.745**	0.208	−0.026
Lack of signage/indicators to show depth or danger	−0.066	0.022	−0.059	0.086	0.124	**0.885**
Behaviour of others, e.g. others driving through without problems	0.021	−0.123	0.046	0.101	**0.804**	0.175
Careful consideration of the situation	**0.625**	−0.090	0.154	0.223	0.046	−0.359
Knowing the road well	0.141	−0.287	**0.662**	0.101	−0.128	−0.047
Driving through floodwater previously without problem	0.094	0.183	**0.666**	0.240	0.063	−0.112
Professional SES training/knowledge	**0.820**	0.062	0.116	0.083	−0.086	0.051
Reassurance or encouragement from others in the vehicle	0.362	0.318	−0.009	−0.002	**0.433**	−0.058
Belief in my own physical ability to drive through	**0.430**	0.078	**0.672**	0.070	−0.037	0.017
Close proximity to destination/operational situation	0.283	0.225	0.303	0.317	0.105	0.323
Gut-feeling that it would be all right	−0.152	0.247	**0.709**	−0.031	0.274	0.097
Being directed to drive through the water by other emergency services/council	−0.055	**0.595**	−0.072	0.221	0.288	−0.230
SES's attitude towards safety	**0.682**	0.135	0.062	0.016	0.104	0.038
Excitement - it being fun to do	−0.008	0.360	0.092	−0.215	**0.487**	0.008
Organisational pressure to complete my duty	0.084	**0.805**	0.048	0.028	−0.021	0.072
My personal desire to complete my duty	0.208	**0.742**	0.206	0.126	−0.054	0.162

Extraction method: principal component analysis.
Rotation method: varimax with Kaiser normalization.
Note. Factor loadings >0.40 are in boldface.

and technological competence that provides the knowledge required to make intuitive decisions." Locus of control research [47] shows that it clearly relates to driving in areas such as skill and accident involvement.

Individuals with an internal locus of control are more attentive, motivated, and adept at avoiding aversive situations; hence, internality is negatively related to accident involvement [47]. Perceived self-efficacy [48] in contexts such as health behaviour change [49–51] has been associated with adaptive behaviours and more positive outcomes. In recent years, route-choice modelling has been the topic of several theoretical studies [52] which indicate that journey characteristics, specifically travellers' route choice, are important in decision-making aspects of driving. For example, Lindsey et al. [53] studied the effects of pre-trip information on route-choice decisions when travel conditions are congested and stochastic, and Yang and Jiang [54] developed an enhanced route choice model which can realistically identify risk attitudes and time reliability demands.

Regarding social influences, in disaster situations where options are often ambiguous and decisions need to be made quickly, it is argued that people often look to see what other people are doing to manage the situation and then act accordingly [55]. Research findings are also evident for the significance of risk signals. Prior research in the United States has found that drivers make judgements on whether to drive through floodwaters based on visual cues in the environment such as depth indicator signs [56,57]. The themes that emerged from factor analyses in the present study are grouped differently to previous psychological research applied to driving though floodwaters [31] where the key influences on driver decision making were themed as successful past experiences, individual deliberative motivational and impulsive influences, social and environmental context, and judgements of self-efficacy.

Table 7
Total variance explained by principal component analysis for influencing factors of decision-making.

Component	Extraction sums of squared loadings		
	Total	% of variance	Cumulative %
1 Organisational training and safety	3.755	20.861	20.861
2 External locus of control	1.986	11.031	31.892
3 Self-efficacy judgements	1.524	8.465	40.357
4 Journey characteristics	1.394	7.747	48.103
5 Social influences	1.131	6.283	54.386
6 Absence of risk signals	1.015	5.640	60.026

3.5. Phase 5: Predicting perceived level of risks from the factors that influence decision-making

Previously research [31] has identified the key influences on driver decision-making. However, how those influences relate with each other and work in a model of decision-making has not been explored. In this final phase of analysis, we sought to use quantitative statistical methods to investigate the link between socio-cognitive influences of risk perception in the set of incidents in which SES personnel drove through floodwater.

A six-step hierarchical multiple regression analysis was performed on the dependent variable of perceived level of risk. The 'Organisational training and safety' factor was entered in step 1. The 'External locus of control factor' was entered at step 2, the 'Self-efficacy judgement' factor at step 3, 'Journey characteristics' at step 4, 'Social influences' at step 5, and 'Absence of risk signals' at step 6. Intercorrelations between the multiple regression factors are reported in Table 8 and the regression statistics are in Table 9.

The hierarchical multiple regression revealed that at stage one, organisational training and safety contributed significantly to the regression model, $F(1,199) = 17.58, p < .01$ and accounted for 8.1% of the variation in perceived level of risk. Introducing the external locus of control factor explained an additional 2.7% of variation in perceived risk level and this change in R^2 was significant, Fchange $(1,198) = 6.002, p < .05$. Adding self-efficacy judgement, Fchange $(1,197) = 0.285, p > .05$ at stage 3; Journey characteristics, Fchange $(1,196) = 2.39, p > .05$ at stage 4 and Social influences, Fchange $(1,195) = 3.08, p > .05$ at stage 5 to the regression model explained additional 0.1%; 1.1% and 1.4% of the variation in perceived risk level, respectively and this change in R^2 was not significant ($p > .05$). Finally, the addition of Absence of risk signals to the regression model explained an additional 2.3% of the variation in perceived risk level and this change in R^2 square was also significant, $F(1,194) = 5.18, p < .05$. When all six independent variables were included in the final stage of the regression model, External locus of control was not a significant predictor of perceived risk. The most important predictor of perceived risk was Organisational training and safety, which uniquely explained 28.5% of the variance. Together the six independent variables accounted for 39.6% of the variance in perceived risk.

The results of the analysis indicated that the organisational training, knowledge and safety factor was significantly negatively associated with perceived risk, and had the most significant contribution to risk perception. It revealed that those who felt their professional skills, training and safety attitudes had a greater influence on their decision to drive through floodwater were more likely to perceive the risk of driving through the

Table 8
Means, standard deviations and bivariate correlations between all variables (influencing factors of decision-making and perceived level of risk) in the model.

Sl.	Variables	1	2	3	4	5	6	Mean	SD
1	Organisational training and safety	–						14.01	4.72
2	External locus of control	0.224**						6.72	4.13
3	Self-efficacy judgements	0.317**	0.203**					16.11	5.98
4	Journey characteristics	0.274**	0.244**	0.287**				12.61	5.17
5	Social influences	0.133	0.264**	0.160*	0.039			6.85	3.52
6	Absence of risk signals	−0.100	0.076	−0.032	0.085	0.138		2.49	1.89
7	Perceived level of risk	−0.285**	0.096	−0.102	0.042	0.103	0.219**	28.01	16.46

* $p < 0.05$.
** $p < 0.01$.

floodwater on that occasion as low. Seemingly, belief in being highly trained and skilled at considering risks in the situation at hand was associated with feeling it was not risky to drive through the floodwater. On the other hand, the external locus of control factor was significantly positively associated with perceived level of risk. This suggests that an increased sense of duty and organisational pressure to perform one's duty was associated with driving through floodwater that was considered higher risk.

Absence of risk signals was the other remaining factor that was linked to perceived risk. The analysis indicated that absence of risk signals (road signage, depth markers, warnings and messages) was significantly positively associated with perception of risk, such that those who felt that an absence of risk signals contributed more to their decision to drive through floodwater also felt it was riskier when they drove through the floodwater.

4. Applications/implications of the study

There is no similar research exploring the situations in which emergency services personnel engage in risky driving behaviour in floodwater, or other contexts. The findings of the study have a number of practical implications for the development of occupational safety management strategies to ensure the safety of the emergency services personnel in operational contexts and to prevent and reduce the number and severity of injuries and associated costs of driving through floodwater on roads.

4.1. Practical implications of the study

4.1.1. Educational awareness, skills training and knowledge

Emergency workers need to be provided with the knowledge and skills to enable them to assess the risk associated with the different floodwater situations they may encounter during their operational activities. This includes understanding of the consequences of those risks and possible preventive measures that may be taken to mitigate risks. As the general policy is not to enter floodwater, there is no current training program in the SES organisation under study that was related to driving in floodwater. The findings of the study revealed that certain groups such as younger personnel (aged 35–55 years), volunteer personnel with <10 years' of service, those who are often deployed in floods and those who frequently drive SES vehicles were more likely to drive through floodwater Additional training or interventions might be designed that are tailored to different groups of personnel, e.g. 'refresher' training for those with longer service, or 'focussed risk analysis training' for those with greater frequency of flood deployment or who work in more dangerous operational conditions for longer periods of time. This study's findings suggest that more training is required for identification of water-related hazards on roads during flood, as well as the development of more effective risk assessment strategies and more effective internal flood risk messaging. Given the prevalence of driving through

Table 9
Summary of hierarchical regression analysis for variables predicting perceived level of risks.

Factors	B	SE B	β	*R*	R^2	ΔR^2	*F*	ΔF
Step 1				0.285	0.081	0.081	17.58**	17.58**
Organisational training and safety	−0.993	0.23	−0.285**					
Step 2				0.329	0.108	0.027	12.01**	6.002*
Organisational training and safety	−1.125	0.24	−0.323**					
External locus of control	0.672	0.27	0.169*					
Step 3				0.331	0.110	0.001	8.07**	0.285
Organisational training and safety	−1.087	0.25	−0.312**					
External locus of control	0.693	0.27	0.174*					
Self-efficacy judgements	−0.105	0.19	−0.038					
Step 4				0.347	0.120	0.011	6.69**	2.390
Organisational training and safety	−1.155	0.25	−0.331**					
External locus of control	0.620	0.28	0.156*					
Self-efficacy judgements	−0.166	0.20	−0.060					
Journey characteristics	0.356	0.23	0.112					
Step 5				0.366	0.134	0.014	6.03**	3.082
Organisational training and safety	−1.181	0.25	−0.339**					
External locus of control	0.500	0.28	0.126					
Self-efficacy judgements	−0.203	0.20	−0.074					
Journey characteristics	0.383	0.23	0.120					
Social influences	0.572	0.32	0.122					
Step 6				0.396	0.156	0.023	5.99**	5.181*
Organisational training and safety	−1.102	0.25	−0.316**					
External locus of control	0.469	0.28	0.118					
Self-efficacy judgements	−0.180	0.19	−0.066					
Journey characteristics	0.323	0.22	0.102					
Social influences	0.465	0.32	0.100					
Absence of risk signals	1.337	0.58	0.154*					

Note. n = 201.
* $p < 0.05$.
** $p < 0.01$

floodwater in work vehicles, increased engagement of personnel around the dangers of driving in floodwater could be beneficial, with the use of photographs, video clips, and scenarios as training tools. Facilitated group discussions may help in influencing risk assessment and decision-making, particularly in complex environments with competing priorities, e.g. personal vs. public safety.

4.1.2. Refining risk assessment strategies

Poor quality risk assessment and risk management, and poor decision-making about risk, have been identified as contributing factors in workplace fatality, injury, disease and ill-health and in many major disasters [58]. Understanding and managing risk is central to achieving the outcomes and targets of the Australian Work Health and Safety Strategy 2012–2022 [59]. The findings of the current research could be used to tailor an effective risk assessments strategy for emergency services.

4.1.3. Improving organisational safety

The general guidance to avoid driving through floodwater and the relatively high prevalence of driving through floodwater reported in this study suggest that organisational policy and practice are not aligned. The need to balance the workplace health and safety of personnel with operational requirements and the risk associated with saving lives presents complex organisational challenges. The results of this study can be used to inform further discussions and act as a baseline for further safety interventions, or serve as a catalyst for policy review and reform.

The results of this study also have implications for existing safety management practices, through exploring common beliefs and attitudes towards safety as part of possible intervention strategies. The findings reveal that more needs to be done to explore the organisational safety climate (the shared perceptions of safety policies and practices among personnel of the organisation) regarding entering floodwater in vehicles.

4.1.4. Flood risk communication public messaging and campaigns

Providing critical safety and preparedness information to help communities prepare for, respond to and recover from emergencies and disasters is one of the major functions of the SES. The findings of the study could help SES design more effective flood risk communication messaging for the public and enhance community emergency response capacity and capability. Identifying factors that influence SES personnel when driving through floodwater might be transferable to the decision-making of the public. Therefore, these research findings may help to design more effective public messaging campaigns to reduce driving through floodwater.

Although it was not an aim of this research to make direct comparisons between the emergency services (SES) and the general public, some tentative demographic comparisons could be possible from the findings of this study and studies of the general public. In terms of the findings being transferrable to the general public, the findings of this study possess useful insights for future research that, if the comparisons could be drawn in meaningful way, could benefit both groups to reduce the risks of driving through floodwater.

5. Strengths and limitations of the study

This study is the first of its kind in Australia to investigate emergency services personnel driving through floodwater. The current study has a number of strengths. The use of a definition of floodwater on the road, and a reference image for estimating the depth of water driven through were important additions to the study that will have resulted in better quality data. The use of an independent research team investigating safety practices and ensuring the anonymity of respondent, should also have improved the integrity of the data. The study was supported by senior management in the SES and the sample size was adequate for statistical power in analysis. The survey collected very detailed information about the contexts and conditions in which SES personnel drove through floodwater, and the data collected has the potential to be very useful for the organisation in understanding the behaviour of its personnel and for improving occupational health and safety. However, like any study of this nature, there are a number of limitations that need to be acknowledged. The first, is that the participants of this study were from an East Coast jurisdiction of SES which might not be representative of all jurisdictions in Australia. Although the sample size is adequate for analysis, statistical findings should be viewed as vigorous, but indicative of the sample, rather than representative of the whole organisation. Moreover, as the study only provides findings from a single Australian State's SES agency, similar research in other states or territories may identify different results, particularly those in northern states more prone to flooding during wet season and with less dense and more dispersed populations.

Second, this is a cross sectional study and provides only a snapshot of a set of incidents, not all incidents, of driving through floodwater. As we requested details about a single recent memorable incident, participants probably recalled more salient, and possibly more extreme, incidents. Although choosing a more salient incident may offset some effects of recall bias, it is possible that a combination of recall bias, especially for less recent incidents, and social desirability (expected social norm) may have influenced the choice of incident reported.

In relation to the degree of risk associated with an incident, we have no way of knowing objectively how risky or safe it was. Assessment of water flow is likely to be subjective, as noted in the vehicle stability study of Smith et al. [20]. Judgement of flow velocity (and often depth) is difficult in real world situations. Additional variables, such as weather-related variables, e.g. poor visibility due to heavy rain or strong wind, may also influence the assessment of water depth and flow. However, the subjective judgement of these attributes is used to inform decision-making and determine behaviour in the situations reported here and therefore the self-report of these characteristics is still a valid measure to explore in this study.

In an organisational situation where SES personnel are discouraged from driving through floodwater, there would potential for embarrassment in admitting to acting unsafely, therefore participants may have felt a need to minimise or excuse their risk-taking in the way they answered some questions, although we would expect that assurances of anonymity and confidentiality would have reduced some of these impacts. Finally, the study included the EPPM theory concepts in the final step of the decision-making model, which proposed that individual's fear, or danger control processes turn mental simulation outcomes into action. However, the study could not assess and interpret clearly how these two processes (fear or danger) relate to risk perception. Further research is required to explore the relevance of the EPPM theory constructs in this decision-making model of driving through floodwater behaviour to further explore and verify the model.

6. Conclusion

This research contributes to our understanding about risk perception and how it relates to driving through floodwater by emergency services personnel. The study found that, despite general guidance not to enter floodwater, more than half of those surveyed had driven through floodwater in the last two years in work vehicles. Males, those doing more driving per week, and volunteers with >10 years SES experience were among some of the groups more likely to have driven through floodwater in the last two years. Most incidents of driving through floodwater occurred in non-urgent responses (i.e. not under lights and sirens), with adequate light (during the day), in good weather condition (no rain), crossing water on a normal stretch of (flooded) road, with low water flow. These factors helped respondents drive through floodwater successfully on most occasions without damage to vehicles or personal injuries. As driving in floodwater is discouraged, it is interesting to consider why many respondents took risks driving through floodwater when they were unable to be certain of the safety of the situation (e.g. water flow, road integrity) to perform non-urgent work. Although there is only a small number of cases, some personnel drove through floodwater in conditions when the risk of harm was perceived to be greater, i.e. through water deeper than 15 cm, at night with no streetlights, in steady or heavy rain, or ignoring road signage.

Location, water depth, and flow contributed notably to risk perception and three factors that influenced the decision to drive through floodwater were found to be most strongly associated with risk perception. These were 'Organisational training and safety', 'External locus of control' and 'Absence of risk signals'. Thus, SES personnel who felt their professional skills and training and careful consideration of the situation contributed to their decision also felt that risks were lower when they drove through floodwater. Conversely, high external locus of control and an absence of risk signals (warnings, signs and indicators) led personnel to perceive higher risks when they drove through floodwater.

The results from this study indicate that more needs to be done to communicate the risks of entering floodwater in work vehicles. These findings identify some key aspects that have salience in risk processing and risk perception that can be used to help design more effective risk assessment strategies, to design training tools and safety programs, and to contribute overall to improvements in workplace health and safety management practices.

Credit authorship contribution statement

Mozumdar Arifa Ahmed: Conceptualization, Methodology, Data curation, Formal analysis, Writing - original draft, Writing - review & editing. **Katharine Haynes:**Conceptualization, Methodology, Resources. **Matalena Tofa:**Project administration, Resources, Visualization, Investigation. **Gemma Hope:**Data curation, Resources, Visualization. **Mel Taylor:** Conceptualization, Methodology, Supervision, Writing - review & editing.

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.

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References

[1] Ahmed MA, Haynes K, Taylor M. Driving into floodwater: a systematic review of risks, behaviour and mitigation. International Journal of Disaster Risk Reduction 2018;31. https://doi.org/10.1016/j.ijdrr.2018.07.007.
[2] Ashley ST, Ashley WS. Flood fatalities in the United States. Journal of Applied Meteorology and Climatology 2008;47(3):805–18. https://doi.org/10.1175/2007JAMC1611.1.
[3] Diakakis M, Deligiannakis G. Vehicle-related flood fatalities in Greece. Environmental Hazards 2013;12(3–4):278–90. https://doi.org/10.1080/17477891.2013.832651.
[4] Kellar DMM, Schmidlin TW. Vehicle-related flood deaths in the United States, 1995–2005. Journal of Flood Risk Management 2012;5(2):153–63. https://doi.org/10.1111/j.1753-318X.2012.01136.x.
[5] Špitalar M, Gourley JJ, Lutoff C, Kirstetter PE, Brilly M, Carr N. Analysis of flash flood parameters and human impacts in the US from 2006 to 2012. J Hydrol 2014;519(Part A):863–70. https://doi.org/10.1016/j.jhydrol.2014.07.004.
[6] Salvati P, Petrucci O, Rossi M, Bianchi C, Pasqua AA, Guzzetti F. Gender, age and circumstances analysis of flood and landslide fatalities in Italy. Sci Total Environ 2018; 610–611:867–79. https://doi.org/10.1016/j.scitotenv.2017.08.064.
[7] Sharif HO, Jackson T, Hossain M, Shafique SBIN, Zane D. Motor vehicle-related flood fatalities in Texas, 1959–2008. Journal of Transportation Safety and Security 2010;2 (4):325–35. https://doi.org/10.1080/19439962.2010.506596.
[8] FitzGerald G, Du W, Jamal A, Clark M, Hou XY. Flood fatalities in contemporary Australia (1997–2008). Emerg Med Australas 2010;22(2):180–6. https://doi.org/10.1111/j.1742-6723.2010.01284.x.
[9] Ahmed MA, Haynes K, Taylor M. Vehicle-related flood fatalities in Australia, 2001–2017; 2019 [Manuscript submitted for publication].
[10] Haynes K, Coates L, Leigh R, Handmer J, Whittaker J, Gissing A, et al. "Shelter-in-place" vs. evacuation in flash floods. Environmental Hazards 2009;8(4):291–303. https://doi.org/10.3763/ehaz.2009.0022.
[11] NSW SES. Flood safety warning following 300 flood rescues. Retrieved from: http://www.ses.nsw.gov.au/news/76365/77179; 2016. [accessed 27 September 2016].
[12] Keech JJ, Smith SR, Peden AE, Hagger MS, Hamilton K. The lived experience of rescuing people who have driven into floodwater: understanding challenges and identifying areas for providing support. Health Promot J Austr 2018;30(2):252–7. https://doi.org/10.1016/j.ijdrr.2017.12.013.
[13] Victoria State Emergency Service. VICSES vehicles entering floodwater. Version 1.0, July 2018. Australia: Melbourne; 2018.
[14] Taylor M, Wiebusch T, Beccari B, Haynes K, Ahmed MA, Tofa M. Improving workplace safety: undertaking organisational research on driving through floodwater to inform safety policy and practice; 2019 [Manuscript submitted for publication].
[15] Yale JD, Cole TB, Garrison HG, Runyan CW, Ruback JKR. Motor vehicle-related drowning deaths associated with inland flooding after Hurricane Floyd: a field investigation. Traffic Inj Prev 2003;4(4):279–84. https://doi.org/10.1080/714040485.
[16] Maples LZ, Tiefenbacher JP. Landscape, development, technology and drivers: the geography of drownings associated with automobiles in Texas floods, 1950–2004. Applied Geography 2009;29(2):224–34. https://doi.org/10.1016/j.apgeog.2008.09.004.
[17] Smith GP, Modra BD, Felder S. Full-scale testing of stability curves for vehicles in flood waters. Journal of Flood Risk Management 2019;12(S2):1–15. https://doi.org/10.1111/jfr3.12527.
[18] Molenaar J, Giesbrecht G, McDonald G. Rescue techniques in submerged vehicles. In: Bierens J, editor. Drowning; 2015. p. 499–503. https://doi.org/10.1007/978-3-642-04253-9_76.
[19] McDonald GK, Giesbrecht GG. Vehicle submersion: a review of the problem, associated risks, and survival information. Aviat Space Environ Med 2013;84(5):498–510. https://doi.org/10.3357/asem.3151.2013.
[20] Smith GP, Modra BD, Tucker TA, Cox RJ. Vehicle stability testing for flood flows [technical report WRL TR2017/07]. Sydney, Australia: Water Research Laboratory, University of New South Wales; 2017.
[21] Gissing A, Opper S, Tofa M, Coates L, McAneney J. Influence of road characteristics on flood fatalities in Australia. Environmental Hazards 2019;18(5):434–45. https://doi.org/10.1080/17477891.2019.1609407.
[22] Gissing A, Haynes K, Coates L, Keys C. Motorist behaviour during the 2015 Shoalhaven floods. Australian Journal of Emergency Management 2016;31(2):25–30.
[23] Klein GA, Calderwood R, Clinton-Cirocco A. Rapid decision making on the fire ground. Proceedings of the Human Factors Society Annual Meeting 1986;30(6). https://doi.org/10.1177/154193128603000616.
[24] Klein GA. Recognition-primed decisions. In: Rouse WB, editor. Advances in man-machine systems research. Greenwich, CT: JAI Press; 1989. p. 47–92.
[25] Allahverdipour H, MacIntyre R, Hidarnia A, Shafii F, Kazemnegad A, Ghaleiha A, et al. Assessing protective factors against drug abuse among high school students: self-control and the extended parallel process model. Journal of Addictions Nursing 2007;18:65–73. https://doi.org/10.1080/10884600701334820.
[26] Lewis I, Watson B, Tay R, White KM. The role of fear appeals in improving driver safety: a review of the effectiveness of fear-arousing (threat) appeals in road safety advertising. International Journal of Behavioural Consultation and Therapy 2014;3(2):203–22. https://doi.org/10.1037/h0100799.
[27] Tay R, Watson B. Changing drivers' intentions and behaviours using fear-based driver fatigue advertisements. Health Mark Q 2003;19(4):55–68. https://doi.org/10.1300/j026v19n04_05.
[28] Popova L. The extended parallel process model. Health Educ Behav 2012;39(4). https://doi.org/10.1177/1090198111418108.
[29] Hamilton K, Peden AE, Pearson M, Hagger MS. Stop there's water on the road! Identifying key beliefs guiding people's willingness to drive through flooded waterways. Safety Science 2016;89:308–14. https://doi.org/10.1016/j.ssci.2016.07.004.
[30] Pearson M, Hamilton K. Investigating driver willingness to drive through flooded waterways. Accid Anal Prev 2014;72:382–90. https://doi.org/10.1016/j.aap.2014.07.018.
[31] Hamilton K, Keech JJ, Peden AE, Hagger MS. Protocol for developing a mental imagery intervention: a randomised controlled trial testing a novel implementation imagery e-health intervention to change driver behaviour during floods. BMJ Journal 2019;9(2). https://doi.org/10.1136/bmjopen-2018-025565.
[32] Hamilton K, Peden AE, Keech JJ, Hagger MS. Driving through floodwater: exploring driver decisions through the lived experience. International Journal of Disaster Risk Reduction 2019;34:346–55. https://doi.org/10.1016/j.ijdrr.2018.12.019.
[33] Hamilton K, Peden AE, Keech JJ, Hagger MS. Changing people's attitudes and beliefs toward driving through floodwaters: evaluation of a video infographic. Transportation Research Part F 2018;53:50–60. https://doi.org/10.1016/j.trf.2017.12.012.
[34] Hamilton K, Price S, Keech JJ, Peden AE, Hagger MS. Drivers' experiences during floods: investigating the psychological influences underpinning decisions to avoid driving through floodwater. International Journal of Disaster Risk Reduction 2018;28:507–18. https://doi.org/10.1016/j.ijdrr.2017.12.013.
[35] Richetin J, Conner M, Perugini M. Not doing is not the opposite of doing: implications for attitudinal models of behavioural prediction. Pers Soc Psychol Bull 2011;37(1). https://doi.org/10.1177/0146167210390522.
[36] Becker JS, Taylor HL, Doody BJ, Wright KC, Gruntfest E, Webber D. A review of people's behaviour in and around floodwater. Weather, Climate, and Society 2015;7(4):321–32. https://doi.org/10.1175/wcas-d-14-00030.1.
[37] Coates L. Flood fatalities in Australia, 1788–1996. Australian Geographer 1999;30(3): 391–408. https://doi.org/10.1080/00049189993657.
[38] Haynes K, Coates L, van den Honert R, Gissing A, Bird D, Dimer de Oliveira F, et al. Exploring the circumstances surrounding flood fatalities in Australia—1900–2015 and the implications for policy and practice. Environ Sci Policy 2017;76:165–76. https://doi.org/10.1016/j.envsci.2017.07.003.
[39] Peden AE, Franklin RC, Leggat P, Aitken P. Causal pathways of flood related river drowning deaths in Australia. PLOS Currents Disasters 2017, May 18. https://doi.org/10.1371/currents.dis.001072490b201118f0f689c0fbe7d437 [Edition 1].
[40] Diakakis M, Deligiannakis G. Flood fatalities in Greece: 1970–2010. Journal of Flood Risk Management 2015;10(1):115–23. https://doi.org/10.1111/jfr3.12166.
[41] Jonkman SN, Kelman I. An analysis of the causes and circumstances of flood disaster deaths. Disasters 2005;29(1):75–97. https://doi.org/10.1111/j.0361-3666.2005.00275.x.

[42] Peden AE, Franklin RC, Leggat P. The flood-related behaviour of river users in Australia. PLOS Currents Disasters 2018, June 14. https://doi.org/10.1371/currents.dis.89e243413a0625941387c8b9637e291b [Edition 1].

[43] Victoria State Emergency Service. 15 to float: never drive on flooded roads. Available from: https://www.ses.vic.gov.au/-/15-to-float-never-drive-on-flooded-roa-1; 2017.

[44] Affum J, Giummarra G, Cheung H. Safety provisions for floodways over roads. (Research report No. AP-R481-15). Retrieved from Austroads website https://austroads.com.au/publications/road-design/ap-r481-15/media/AP-R481-15_Safety_Provisions_for_Floodways_Over_Roads.pdf; 2015.

[45] Bandura A. Self-efficacy: toward a unifying theory of behavioural change. Advances in Behaviour Research and Therapy 1978;1(4):139–61. https://doi.org/10.1016/0146-6402(78)90002-4.

[46] Rogers CT. Intuition: an imperative of command. Military Review 1994:38–50.

[47] Montag I, Comrey AL. Internality and externality as correlates of involvement in fatal driving accidents. J Appl Psychol 1987;72(3):339–43. https://doi.org/10.1037/0021-9010.72.3.339.

[48] Bandura A. Self-efficacy: the exercise of control. New York, NY: Freeman; 1997.

[49] Hamilton K, Warner LM, Schwarzer R. The role of self-efficacy and friend support on adolescent vigorous physical activity. Health Educ Behav 2017;44(1):175–81. https://doi.org/10.1177/1090198116648266.

[50] Zhou G, Gan Y, Hamilton K, Schwarzer R. The role of social support and self-efficacy for planning fruit and vegetable intake. J Nutr Educ Behav 2017;49(2):100–6. https://doi.org/10.1016/j.jneb.2016.09.005.

[51] Zhou G, Sun C, Knoll N, Hamilton K, Schwarzer R. Self-efficacy, planning and action control in an oral self-care intervention. Health Educ Res 2015;30(4):671–81. https://doi.org/10.1093/her/cyv032.

[52] Juhász J. Influence of different route-choice decision modes. Transportation Research Procedia 2017;27:246–52. https://doi.org/10.1016/j.trpro.2017.12.058.

[53] Lindsey R, Daniel T, Gisches E, Rapoport A. Pre-trip information and route-choice decisions with stochastic travel conditions: theory. Transportation Research Part B: Methodological 2014;67:187–207. https://doi.org/10.1016/j.trb.2014.05.006.

[54] Yang J, Jiang G. Development of an enhanced route choice model based on cumulative prospect theory. Transportation Research Part C: Emerging Technologies 2014;47(Part 2):168–78. https://doi.org/10.1016/j.trc.2014.06.009.

[55] Aronson E, Wilson TD, Akert RM. Social psychology. . 7th edSaddle River, NJ: Pearson; 2010.

[56] Balke K, Higgins L, Chrysler S, Pesti G, Chaudhary N, Brydia R. Signing strategies for low-water and flood-prone highway crossings. (No. FHWA/TX-12/0 6262-1). Available from: http://tti.tamu.edu/documents/0-6262-1.pdf; 2011.

[57] Higgins L, Balke K, Chrysler ST. Driver responses to signing treatments for flooded roads. Transportation Research Record 2012;2321(1):98–107. https://doi.org/10.3141/2321-13.

[58] Dekker S, Cilliers P, Hofmeyr JH. The complexity of failure: implications of complexity theory for safety investigations. Safety Science 2011;49(6):939–54. https://doi.org/10.1016/j.ssci.2011.01.008.

[59] Safe Work Australia. Healthy, safe and productive working lives. Australian Work Health and Safety Strategy 2012–2022; 2016 Available from: https://www.safeworkaustralia.gov.au/about-us/australian-work-health-and-safety-strategy-2012-2022.

[60] Drobot SD, Benight C, Gruntfest EC. Risk factors for driving into flooded roads. Environ Hazard 2007;7(3):227–34. https://doi.org/10.1016/j.envhaz.2007.07.003.

[61] Klein GA. Naturalistic decision making. Sources of power. How people make decisions. Cambridge, MA: MIT Press; 1998.

[62] Taylor F, Archer F, Bird D, Paton D. Lessons from the Flood Safe program: Why people do and do not prepare for floods. Paper presented at Floodplain Management Australia Conference. Nowra, NSW, Australia.; 2016.

[63] Australian Government Geoscience Australia. Flood Terms, Geoscience Australia; 2014 Retrieved from: http://www.ga.gov.au.