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Driving into floodwater: A systematic review of risks, behaviour and mitigation



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ABSTRACT

This systematic review summarises the findings of research focused on the risks associated with driving into floodwater. The review aims to compare and document the magnitude of the problem internationally; identifying the risk factors; exploring the application of theories and presence of theoretical models to explain people's risky behaviour; and documenting the intervention strategies utilised or proposed. Literature were searched from a number of databases (e.g. PsycInfo, ScienceDirect, Informit) for publication dates to 31 August 2017, then assessed based on their titles, abstracts and full texts and finally 24 articles were selected. This review compares flood fatality data from four countries (Australia, United States, Greece, and Sweden), groups identified risk factors from these selected studies into seven categories, and proposes a holistic integrated intervention model. The results of the review indicate that studies were predominantly conducted in Australia (10 studies) and USA (7 studies). People's decisions to drive into, or turn back from, floodwater are identified as a consequence of both their risk perception and the combined impact of all other factors (e.g. individual, social, environmental etc.) that interdependently contribute to shape decision-making. The theory of Planned Behaviour (TPB) was the only theory that has been utilised within the literature to understand drivers' willingness to take risks. Improving people's decision-making through educational initiatives, advanced structural mechanisms, regulating existing edicts, and regularly evaluating the effectiveness of current strategies are identified as the best approaches to addressing the challenges in this area. Findings suggest that future studies require data and analysis from a larger range of countries, more comparative analyses within and between countries, an exploration of the relationship between risk factors and their relative level of influence and a greater application of behavioural and decision making theories.

1. Introduction

Floods are the highest cause of mortality due to drowning throughout the world [5,41]. Previous literature notes that driving through floodwater is a common flood experience [17] and constitutes a major cause of flood fatalities globally [11,15,25–27,32,41,42,45]. Despite its importance as a cause of flood-related mortality, motor vehicle-related drowning as well as the risk perceptions and motivations of people in undertaking this risky behaviour remain poorly understood.

The number of studies and reviews within this field are limited with the majority being country-specific or focused on specific locations. Furthermore, many flood-related research studies have investigated a broad set of risk factors, rather than focusing on driving-related behaviour per se, and few have applied a theoretical approach to explain

people's decision-making. Thus, an international review was considered necessary to draw lessons from across the international literature, to consolidate our understanding of the nature and patterns of people's driving behaviour in flood situations, to identify interventions being employed or suggested to reduce risks, and to identify research gaps.

The main objectives of this review, therefore, are: to quantify the impacts of driving into floodwater (through review of fatality data); to identify the factors that influence the decisions of people to drive into floodwater; to explore the application of different theories and models that may explain perceptions and complex decision-making processes; and to explore possible interventions to engage the public and reduce risks. To fulfill the objectives, the study will present and compare the number of vehicle-related flood deaths in different countries, categorise and explore the risk factors, and develop a holistic intervention framework. The study will also identify priority research gaps for further

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study in the context of driving into floodwater.

2. Methods

2.1. Study design

This study used a systematic literature review in order to investigate past research that considered the action of driving into floodwater and specifically any patterns, risk factors, and possible interventions. A systematic literature review protocol was prepared to guide the development of the study objectives, questions, inclusions and exclusions criteria, and then search strategies were developed. This protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on 18 July 2017 and was last updated on 31 August 2017 (registration number CRD42017071343).

2.2. Inclusion and exclusion criteria

The inclusion criteria used for this systematic review were: studies conducted in all regions across the world; original articles that have been published in peer reviewed journals; and studies that included motor vehicle-related flood experience. There was no restriction applied to the date of studies sampled, and all databases were searched for studies published up to the 31 August 2017. Exclusion criteria included studies not related to driving and vehicles, non-English language articles, and studies on other natural hazards. The protocol developed for this study led to the identification of 24 relevant articles fulfilling these criteria.

2.3. Information sources and search strategies

The sources of information used for this systematic review were PsycInfo, ScienceDirect, Taylor and Francis Online, ProQuest, American Meteorological Society (AMS), Springer Link, Wiley Online Library, Informit, and the Australian Bushfire and Natural Hazards Cooperative Research Centre (CRC) databases. A search for relevant articles was also conducted in Google scholar. The search terms used for the review were; ‘flood’, ‘risk’, ‘drowning’, ‘driving’ and ‘vehicles’. See Table 1 for search strategies used in this review.

2.4. Study selection

This review adopted a three-stage screening process for selecting potential studies. Firstly, articles were assessed based on their titles, and secondly on the basis of abstracts in order to exclude articles not fulfilling the inclusion criteria. Finally, the remaining articles’ full texts

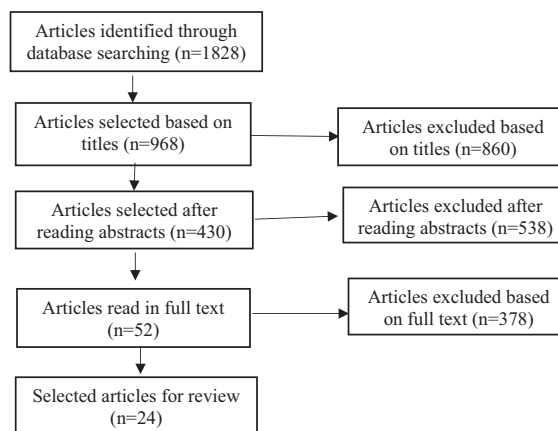


Fig. 1. Article selection flow chart.

were accessed and read, and at this stage, articles that did not meet the set of inclusion criteria were rejected. See Fig. 1 for the article selection flowchart.

2.5. Data extraction and management

Two reviewers independently extracted data from all sources using pre-prepared and piloted data extraction forms based on the review objectives. Extracted information included: study goals, methodology, study area, study population and participant demographics, theoretical basis, types of analyses, results of studies (including number of vehicle-related flood incidents and fatalities), factors associated with risks, and suggested interventions. Finally, all extracted information was cross-checked and accepted by reviewers after discussions. Endnote X8 was used to manage the references. Reviewers also assessed the methodological quality of the included studies which involved critical appraisal of the methods of data collection, the type of statistical analyses, quality of reporting, and other potential sources of bias.

2.6. Data synthesis

A systematic narrative synthesis was conducted. First, a preliminary synthesis of findings of included studies (tabulation and groupings) was undertaken. This was followed by an exploration of the relationship and findings both within and between the included studies and an assessment of the robustness of the synthesis. See the Fig. 2 for synthesis process conducted by this review.

2.7. Assessment of the risk of failure

Assessment of the risk of failure (for instance missing important information due to systematic bias in the search methodology) was conducted, independently, by two reviewers from different disciplines; psychology and geography. This assessment involved critically appraising the methods of data collection, the type of statistical analyses, quality of reporting and other potential sources of bias (for example publication bias, in which only positive results are published and therefore over-represented).

3. Results

From all databases, 968 titles, 430 abstracts and 52 full texts of articles were assessed for eligibility criteria. A total of 24 articles fulfilling the inclusion criteria were selected to be reviewed. A list of the selected studies and justification for their selection in this review is presented in Table 2.

A descriptive summary of the characteristics of the selected studies,

Table 1
Search Strategies.

Keywords	Databases	Search Outcome	Last date of search
("risky behavio*" OR "risk*" OR "willingness" OR "driving behavio*" OR "reasoned action" OR motivation) AND ("flood*" OR "flashflood") AND ("vehicle*" OR "automobile*" OR "car" OR "cars")	Wiley Online Library PsycInfo Taylor and Francis Online Springer ScienceDirect American Meteorological Society ProQuest Informit Bushfire and Natural Hazards Cooperative Research Centre	647 330 320 226 145 66 45 30 19	21/08/2017; 12:12 p.m.

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