



Auditing learner driver information about floodwaters: An environmental scan of government issued resources in Australia

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ABSTRACT

Introduction: Vehicles driving, or being swept, into floodwaters is a leading cause of flood-related death. Establishing safe behaviors among learner drivers may reduce risk throughout their driving lifetime. **Methods:** An environmental scan of publicly available government issued learner and driver handbooks across the eight Australian jurisdictions was conducted to identify information provided regarding floodwaters. Search terms included 'flood,' 'rain,' 'water,' and 'wet.' A visual audit of flood-related signage was also conducted. **Results:** Twelve documents, across eight jurisdictions, were analyzed. Four jurisdictions' documents provided no information on flooding. Of the four jurisdictions that provided information, content varied. This included highlighting risks and discouraging entering floodwaters in a vehicle, including penalties associated with travel on closed roads, to advising depth and current checks if crossing a flooded roadway, with recommendations based on vehicle size (preference given to bigger vehicles, i.e., 4wds). Information on flood-related signage was found in one jurisdiction. **Discussion:** Learner and driver handbooks represent a missed opportunity to provide flood safety information. Currently, information is not provided in all jurisdictions, despite flood-related vehicle drowning deaths of drivers and passengers being a national issue. Where information is presented, it is limited, often lacks practical guidance on how to assess water depth, current, and road base stability, and could better use evidence regarding the psychological factors underpinning, and behavioral prompts for performing, or avoiding, risky driving behavior during floods. **Conclusions:** The provision and content of information in learner driver and driver handbooks must be improved, particularly within the context of increasing flooding and extreme weather associated with the effects of climate change. **Practical applications:** We encourage all jurisdictions to provide practical information that draws on evidence-based risk factors and empirically established psychological factors for behavioral change to help establish safe driver behaviors around floods in the formative years of learning to drive.

1. Introduction

Drowning is an injury and behavioral issue linked to climatic conditions (Sindall et al., 2022). Excessive heat and heatwaves prompt people to enter the water to seek relief (Peden et al., 2023); water storage in and around the home during periods of drought increases drowning risk for young children; and heavy rainfall can cause riverine and flash flooding in urban and rural environments alike (Sindall et al., 2022).

During times of flood, drowning is a leading cause of death,

accounting for an estimated 75% of all deaths (Jonkman et al., 2008). Deaths predominately occur due to unsafe or dangerous human behaviors, combined with hazardous environmental conditions (Hamilton et al., 2020). In most high-income contexts, vehicle-related incidents are a leading cause of loss of life due to flood-related drowning (Ashley & Ashley, 2008; Diakakis & Deligiannakis, 2013; Peden, Franklin, Leggat, & Aitken, 2017). Such incidents occur when vehicles drive or are swept into floodwaters covering or inundating roadways. The depth and the velocity of the water interact to lift the vehicle from the road base causing it to float and wash away. People can become trapped in

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inundated cars or be swept away when trying to exit their vehicle (Gissing et al., 2023).

In Australia, riverine flooding is the most common, with an annual average of 13 unintentional riverine flood-related drowning deaths between 2002 and 2012 (Peden et al., 2017). Of these, 55% were due to non-aquatic transport, most commonly deaths of drivers or their passengers who have driven into or been swept into floodwaters in their vehicle (Peden et al., 2017). More recently, of the 96 vehicle-related flood fatalities in Australia between 2001 and 2017, over half of the decedents were drivers (60%), although the decisions of drivers led to the deaths of 30 passengers as well (Ahmed et al., 2020).

Behavioral research among drivers who have driven into floodwaters shows a range of factors guiding the decision, including pressure to get to work or school, needing to get home to family or pets, and pressure from other motorists; while disapproval from loved ones, fear of damaging their vehicle, and safety concerns are factors underpinning avoidance of driving into floodwaters (Hamilton et al., 2019, 2016, 2018). Qualitative insights from these studies uncovered that some drivers first experienced driving into floodwaters at the encouragement of their supervising driver (often a parent or friend) while learning to drive (Hamilton, Peden, Keech, & Hagger, 2019).

Such insights prompted research with learner drivers themselves, identifying that modeling safe driving behaviors around floodwaters for young passengers is important, with past experience as a passenger correlating with higher willingness to drive into floodwaters. The research also called for the development of theory-based targets, as well as communicating the importance of those supervising learner drivers to establish expectations around avoiding driving into floodwater (if such conditions are encountered on a driving route; or to discuss safer driving behaviors in the case that a flooded road is not encountered) during the supervised driving hours in Australia's graduated driver licensing schemes (Hamilton, Keech, Peden, & Hagger, 2023).

Graduated driver licensing schemes, which include driver education, have been found to be an effective intervention to reduce road traffic injury and death among adolescents (Peden et al., 2023). The evidence however, is less clear, regarding the impact of driver education programs alone (Bates et al., 2018). Nevertheless, learner driver and driver handbooks provide information on driving regulations and safe driving behaviors, which form the basis of a driver knowledge test within a graduated driver licensing scheme. Thus, these handbooks represent one avenue to communicate the dangers of driving into floodwaters as well as strategies to implement in times of flood to avoid driving into floodwaters. Yet, to decide on relevant content to communicate, first a

comprehensive audit needs to be conducted to gather knowledge on what flood safety information is currently provided in such resources across the six states and two territories (eight jurisdictions) of Australia.

2. Materials and methods

This study used an environmental scan methodology, which is a method for reviewing online material through a systematic search (Charlton et al., 2019), to examine the current provision of flood safety information in publicly available government issued learner driver and driver handbooks.

Using the search string 'Learner driver handbook' and the relevant state or territory acronym 'ACT' [Australian Capital Territory] (i.e., *Learner driver handbook ACT*), a Google search (www.google.com.au) was used. Searches were conducted for all Australian states ($n = 6$) and territories ($n = 2$), thus eight jurisdictions (see [Supplementary Table 1](#)). Using the search results, we navigated to the page and downloaded the relevant PDF resource. Where a learner driver specific resource was identified, this was used. Where no learner driver specific material was identified via searching, a general driver or road user handbook was used instead (see results). Searches were run and documents downloaded on October 7, 2023.

Once downloaded, each document was opened, and the Adobe PDF search function was used to locate the keyword 'flood' within each document. Subsequent rounds of keyword searching were used for broader but related terms such as 'rain,' 'water,' and 'wet.' Terms related to the use of water in the vehicle or having drinking water, for example, were not extracted as not within scope for this study.

Where matches for search terms were identified, the corresponding text was extracted verbatim from the resource and summarized into a table, indicated alongside the relevant sub-section of the document it appeared in. The absence of information was also documented.

In addition, a visual audit of signage symbols shown in each resource was conducted to check for signage related to flooding, such as water over road signs, road closed due to flooding signs, and depth markers. The presence or absence of this information, including the surrounding explanatory information, if present, was also extracted. Due to the use of publicly accessible information, human research ethics approval was not required for this study.

3. Results

A learner driver or driver information handbook was identified in

Table 1
Relevant information identified through environmental scan by Australian state or territory jurisdiction.

Jurisdiction (abbreviation)	Resource name (Published date)	Learner-specific? (Yes/No)	Reference
Australian Capital Territory (ACT)	ACT Road Rules Handbook (January 2019)	Yes	(ACT Government, 2019)
New South Wales (NSW)	Road User Handbook (2023)	Yes	(Transport for NSW, 2023)
Northern Territory (NT)	Learner Drivers' Guide: Your guide to basic driving procedures in the Northern Territory (January 2020)	Yes	(NT Government, 2020)
	Road Users Handbook: Your guide to safely sharing the roads in the Northern Territory (August 2020)	No	(NT Government, 2020)
Queensland (QLD)	Your keys to driving in Queensland (November 2022)	Yes	(QLD Government, 2022)
South Australia (SA)	Drivers' Handbook (April 2022)	Yes	(Government of SA, 2022)
	The Driving Companion (June 2022)	Yes	(Government of SA, 2022)
Tasmania (TAS)	Tasmanian Road Rules (August 2022)	No	(TAS Government, 2022)
Victoria (VIC)	Guide for Learners: Learner Kit (March 2023)	Yes	(VIC Roads, 2023)
	Guide for Supervising Drivers: Learner Kit (March 2023)	Yes	(VIC Roads, 2023)
	Road to Solo Driving (April 2023)	Yes	(VIC Roads, 2023)
Western Australia (WA)	Drive Safe: A handbook for Western Australian road users (July 2023)	Yes	(WA Government, 2023)

Table 2

Identified information on flood safety via 'flood' keyword search and relevant information.

Jurisdiction (reference)	Keywords	Presence (Y/N)	Section/ sub-section	Relevant information
Australian Capital Territory (2019)	Flood	N	–	–
New South Wales (2023)	Flood	Y	Driving through water	“You should avoid driving through water. It can be very risky. There’s a limit to the depth of water that your vehicle can drive through safely. It’s difficult to assess how deep and fast water is when it’s moving over a road. The road surface under the water may be damaged or there may be debris, or the water level may be rising. Floodwater is extremely dangerous. Find another way or wait until the road is clear. It’s safer to turn around than to drive in floodwater.” (pg 180–181)
Northern Territory (2020)	Flood	Y	Your vehicle and driving conditions	“If you encounter a flooded road, check the depth, strength of the water flow and the possibility of obstructions before proceeding or wait until the water has subsided. Do not travel on roads that are closed – heavy penalties apply. Regularly updated road condition reports are available by phone on 1800 246 199 or by visiting the NT road report website or Facebook page.” (pg 20)
Northern Territory (2020)	Flood	Y	Road conditions	“Two-wheel drive vehicles can be driven on most gravel roads, while a four-wheel drive vehicle is recommended for dirt roads. In the wet season, some gravel roads will require a four-wheel drive vehicle, especially at creek crossings and flood ways.” (pg 55)
			Water on the road	“Some roads in the Northern Territory are prone to flooding. If you come across a flooded road: check the depth; do not drive through water at speed- fast flowing water can be like hitting wet concrete; be aware that if you cannot see the road surface, obstructions may be present or wash outs may have occurred. If in doubt do not cross; fast flowing water can make your car float. If in doubt do not cross; be alert for crocodiles as they inhabit many waterways in the north; wait until the water level drops. Never attempt to cross a flooded road where there are ‘road closed’ signs or other traffic controls in place indicating that the road is impassable. If attempting to cross and you cannot see the line markings or the road, use roadside markers and guide posts to help you stay on track. After going through water, always check the brakes are working properly. If water has reached the brakes they might not be as effective as usual. An easy way to dry out brakes is to drive for a short distance with your foot pressing gently on the brake. “ (pg 56)
Queensland (2022)	Flood	Y	Hazards – road closures due to flooding and wet weather	“Flood waters can be fast moving. For your safety, don’t drive on roads covered by water. If it’s flooded, forget it; Plan your journey by checking qldtraffic.qld.gov.au or by downloading the QLDTraffic App for current traffic conditions and road closures. Alternatively call 13 19 40 to check road conditions or report a road issue; Be alert for changed road conditions, especially any loose debris from surrounding vegetation and river banks; When floodwater starts to go down, don’t drive over roads or bridges until they have been declared open again by the authorities; Due to increased driver concentration when driving in poor conditions, plan regular rest stops, especially on your longer journeys; Follow directions from roadworkers, transport inspectors and emergency service personnel; Do not ignore ROAD CLOSED signs. They are there for a reason. Penalties apply. “ (pg 151)
South Australia (2022)*	Flood	N	–	–
South Australia (2022)	Flood	N	–	–
Tasmania (2022)	Flood	N	–	–
Victoria (2023)	Flood	N	–	–
Victoria (2023)	Flood	N	–	–
Victoria (2023)	Flood	N	–	–
Western Australia (2023)	Flood	Y	Country driving	“When driving in the country: Don’t stop on or near bridges, floodways or on narrow sections of roadway” (pg 48)
			Crossing water on roadways	“Floodways and river crossings are dangerous places. Inexperienced drivers should use an alternative route if one is available. However, if there is no alternative route, before crossing water on the road such as floodways, streams or rivers, always check: the depth of the water by getting out of the vehicle and physically walking the intended crossing if it is safe to do so. If the water is not flowing, the water level should be no higher than the bottom of the vehicle on conventional 2 wheel drive vehicles and no higher than the average adult’s knee (when standing) on higher 4 wheel drive vehicles. If the water is flowing and deeper than the bottom of the vehicle’s chassis, do not cross. Do not cross if the water level is too deep or fast flowing.” (pg 50)

Note: * Information on water on the road is provided but floods and floodwaters are not mentioned.

each of the eight jurisdictions in Australia. In addition, a guide for supervising drivers was found with the search in the state of Victoria. One jurisdiction did not provide a separate learner driver resource (Tasmania). [Table 1](#) lists these resources by Australian jurisdiction and if they are specific to learner drivers or not.

When searching for the term ‘flood’ to identify the relevant flood information being provided, an absence of any information was found in half (i.e., four) of the Australian state and territory jurisdictions (Australian Capital Territory, South Australia, Tasmania, and Victoria). The provision of information from the other four jurisdictions varied, although all resources mentioned the risky nature of flooded roads and entering floodwaters in a vehicle, and all jurisdictions identified the depth and speed of the water as contributing to the danger. Only one jurisdiction, Western Australia ([Western Australian Government, 2023](#)), provided practical tips on how to assess the depth of water and guidance on appropriate depth relative to vehicle type. See [Table 2](#) for the information identified on flood safety via ‘flood’ keyword search for each jurisdiction.

Two of the four jurisdictions that provided flood information (New South Wales and Queensland) discouraged driving into floodwaters, instead encouraging drivers to plan ahead, find alternative routes, or wait until floodwaters had subsided and roads had reopened ([Transport for New South Wales, 2023](#); [Queensland Government, 2022](#)). Driver handbooks in both the Northern Territory and Western Australia advise actions to take if roads are flooded and no alternative routes are available, including walking through water first (although a further instruction suggests not to walk through if the water level is too deep or is flowing too fast), and how to dry brakes after driving through floodwaters ([Northern Territory Government, 2020](#); [Western Australian Government, 2023](#)). These documents also make recommendations around vehicle type, specifically that four wheel drives are the recommended vehicle for dirt roads or gravel roads during wet season ([Northern Territory Government, 2020](#)), and that if water is not flowing, four wheel drives can drive through deeper water (no higher than the average adult’s knee when standing) than conventional two wheel drive vehicles ([Western Australian Government, 2023](#)) ([Table 2](#)).

In only two jurisdictions, Northern Territory ([Northern Territory Government, 2020](#)) and Queensland ([Queensland Government, 2022](#)), were penalties associated with driving on roads that have been closed to traffic due to flooding mentioned. Western Australia was the only jurisdiction to mention the experience level of the driver, discouraging inexperienced drivers from crossing floodways and river crossings, instead encouraging drivers to find an alternative route ([Western Australian Government, 2023](#)). In three jurisdictions, there was mention of the need to consider the integrity of the road base underneath floodwaters and road conditions once floodwaters have subsided, though no guidance on how to assess this was provided ([Transport for New South Wales, 2023](#); [Northern Territory Government, 2020](#)) (see [Table 2](#)).

Additional searches for terms such as ‘rain,’ ‘water,’ and ‘wet’ identified further information with some relevance to driving into floodwaters. In particular, this included driving to conditions in the rain (such as maintaining lower speed and greater braking distance, as well as using headlights) and strategies around checking brakes if having driven through water ([Australian Capital Territory Government, 2019](#)) (see [Supplementary Table 2](#)).

Visual depictions of signage mentioning flood or depth markers were only present in one jurisdiction (New South Wales) ([Transport for New South Wales, 2023](#)). The information comprised visual depictions and information concerning two types of flood signage, namely ‘floodway’ signage that depicts a causeway, as well as a ‘road subject to flooding sign.’ A visual depiction and definition of depth markers as a ‘measure of the depth of floodwater across a road’ was also provided in New South Wales (see [Table 3](#)).

4. Discussion

Drowning in vehicle related incidents (either due to driving, or being swept into floodwaters), is a leading cause of death during times of flood ([Jonkman, Vrijling, & Vrouwenvelder, 2008](#); [Peden et al., 2017](#)), and is predicted to grow with the increased frequency and severity of flooding under a changing climate ([Intergovernmental Panel on Climate Change, 2021](#)). Despite the inherent risks associated with driving into floodwaters, research has identified a range of beliefs that predict learner driver willingness to drive into floodwaters such as perceived social approval from others (including their supervising driver), and past experience as a passenger in vehicles driven into floodwaters ([Hamilton, Keech, Peden, & Hagger, 2023](#)). This indicates the need for driving supervisors, as well as parents and caregivers, to model safe behaviors, as well as educate learner drivers on the dangers of floodwaters. This can be supported by information presented in learner driver or driver handbooks. To encourage safer driver behaviors with respect to flooded roads early in a drivers’ lifetime, we sought to audit the information provided regarding driving into floodwaters in learner driver or driver handbooks. Our findings, discussed below, have important implications for policy makers.

We identified a total absence of information regarding floodwaters in half of all Australian states and territories, namely in the Australian Capital Territory, South Australia, Tasmania, and Victoria. This is concerning given vehicle flood-related deaths of drivers and their passengers have occurred in all Australian states and territories and among residents of all states and territories ([Ahmed et al., 2020](#); [Peden et al., 2017](#)). Even where jurisdictions believe the risk may be low in their own state or territory, those who may learn to drive in their jurisdiction may move or travel interstate, facing risks in other locations. Similarly, the predicted increase in extreme weather due to the effects of climate change will impact all jurisdictions in Australia in the near future ([Intergovernmental Panel on Climate Change, 2021](#)). It is recommended that all jurisdictions incorporate information on flood safety that is based in evidence and incorporates expert opinion, into their learner driver and driver handbooks at the next available opportunity (i.e., upon the next revision of the materials) and immediately as supplemental resources to current handbooks.

Where information was provided in the other four jurisdictions (New South Wales, Northern Territory, Queensland, and Western Australia), the information presented was diverse. Two jurisdictions, Queensland and New South Wales, discouraged driving into floodwaters, suggesting finding alternate routes, making alternative plans, or delaying travel. Given the high burden of vehicle-related flood fatalities (84%) in these jurisdictions between 2001 and 2017 ([Ahmed et al., 2020](#)), it seems apparent that these jurisdictions are making efforts to educate people, drawing somewhat on the evidence to design their messaging. Likely indicative of the tropical climate in the Northern Territory and the north of Western Australia (which experience regular wet seasons and flooding, as well as their remote geography), both jurisdictions were more permissible to driving into floodwaters suggesting actions to take, including drying brakes after driving through floodwaters and appropriate depths based on vehicle type ([Northern Territory Government, 2020](#)). It must be acknowledged, however, that some advice lacks practical guidance (i.e., how to assess the road base and road conditions when water is over the road), and in some instances, may put people in danger and their lives at risk.

What was consistent across the four jurisdictions that provided content, although expressed in different ways, was the risky nature of flooded roads and entering floodwaters in a vehicle, and how the depth and speed of the water across the roadway contributed to the level of danger. However, few jurisdictions mentioned depth markers, and only one jurisdiction explained their purpose ([Transport for New South Wales, 2023](#)). Only one jurisdiction (Western Australia) provided practical guidance on how to assess water depth, in particular in relation to vehicle size ([Western Australian Government, 2023](#)). This information

Table 3

Presence of flood signage or depth markers.

Jurisdiction (reference)	Signage type	Presence (Y/N)	Content
Australian Capital Territory (2019)	Flood signage	N	–
	Depth markers	N	–
New South Wales (2023)	Flood signage	Y	“Floodway – Advises that the sign indicates that a causeway ahead may be covered in water & provides a definition of a causeway” (pg 169)
		Y	“Road Subject to Flooding, Indicators Show Depth – Advises that the road ahead may be covered by floodwater” (pg 169)
	Depth markers	Y	“A measure showing the depth of floodwater across a road” (pg 169)
Northern Territory (2020)	Flood signage	N	–
	Depth markers	N	–
Northern Territory (2020)	Flood signage	N	–
	Depth markers	N	–
Queensland (2022)	Flood signage	N	–
	Depth markers	N	–
South Australia (2022)	Flood signage	N	–
	Depth markers	N	–
South Australia (2022)	Flood signage	N	–
	Depth markers	N	–
Tasmania (2022)	Flood signage	N	–
	Depth markers	N	–
Victoria (2023)	Flood signage	N	–
	Depth markers	N	–
Victoria (2023)	Flood signage	N	–
	Depth markers	N	–
Victoria (2023)	Flood signage	N	–
	Depth markers	N	–
Western Australia (2023)	Flood signage	N	–
	Depth markers	N	–

should be considered cautiously, with minimal water depth needed to lift even larger vehicles off the roadway (Gissing et al., 2023), as well as the overrepresentation of larger and heavy vehicles in vehicle-related flood fatalities in Australia (Peden et al., 2017). In addition to water depth, the risk of driving into floodwaters is exacerbated by the velocity of the water (Gissing et al., 2023); however, no jurisdiction provided practical guidance on assessing the speed of water over a roadway, aside from walking through the water first (Western, 2023), which may present even greater injury risk. Many jurisdictions advise not to drive on roads that are closed, due to punitive punishments associated with breaking the law, yet in reality very rarely is this enforced (Gissing et al., 2023).

4.1. Practical Applications

This preliminary research identified current information provided to learner drivers on driving into floodwater, providing opportunity to consider how the information is conveyed and practically implemented.

Based on the findings of previous research (Hamilton, Keech, Peden, & Hagger, 2023), learner driver and driver handbooks could develop content based on the psychological beliefs and behavior change strategies known to impact individuals’ (and in particular learner drivers’) willingness to drive into floodwater, such as attitude, via strategies like persuasive communication (Hamilton & Johnson, 2020). Embedding the tools to support learner drivers in making an ‘if-then’ plan if they encounter flooded roadways when in their vehicle is also recommended, given evidence to support their role in changing driver behaviors around floods (Hamilton et al., 2022).

Given the role of support and pressure from important others (subjective norm) and modeling safe driving behaviors in floods (perceived behavioral control) (Hamilton, Peden, Keech, & Hagger, 2019), there is also an opportunity to improve the information provided to supervisors of learner drivers which is currently lacking. We encourage policy makers in all jurisdictions to engage with experts and provide evidence-based information to encourage the establishment of safer driver behaviors around floods during the formative years of learning to drive.

Further, in line with a three E's approach to safety (Groeger, 2011), policy maker could consider supplementing educational (and engineering) approaches with strengthened policy responses, including greater enforcement of dangerous driving charges (including manslaughter in cases of the death of a passenger) and punitive punishment for those who knowingly drive past road closed signs.

4.2. Strengths and limitations

This is the first study to the authors' knowledge to systematically examine the information regarding driving and floodwaters provided to learner drivers in publicly available government issued resources. A rigorous, systematic approach was used to identify current information given, thereby signposting important knowledge gaps and opportunities for improvement in the content and delivery of the information provided. Search terms related to flood, such as 'rain,' 'water,' and 'wet' were also searched to find all information relevant to the study aim. However, study findings must be considered in light of some limitations. Despite the detailed document search conducted, some relevant materials may have been missed if not publicly available online, although given the nature of these documents, this is an unlikely scenario. Also, within the documents themselves, outside of the terms searched, relevant information may have been provided that was not extracted. Future research may benefit from also including qualitative methods to gather information from other relevant sources such as driving instructors, flood first responders, and policy makers. This research is a first step in identifying current information provided to learner drivers in publicly accessible government issued learner driver and driver handbooks across Australia. Future research could focus on improving information content and delivery, drawing on evidence-based risk factors and empirically established psychological factors underpinning, and behavioral prompts for, performing or avoiding risky driving behaviors in times of flood.

5. Conclusions

Given research indicating people have driven into floodwaters while learning to drive, it is important that learner driver and driver handbooks provide information on the risks associated with driving into floodwaters and empirically supported strategies on how to manage these risks safely. Gaps identified in this study inform recommendations for the improvement of information provision, as well as opportunities to deliver messages based in evidence and behavioral psychology strategies identified in previous research. The improvement of information provided regarding driving into floodwaters will be important for both learner drivers and their supervisors and may contribute to safer driving behaviors throughout a person's driving lifetime.

Author contributions

AEP and KH conceptualised the study, conducted the searches and extracted and analysed the data. AEP wrote the original draft and KH reviewed and revised the draft. Both authors approve the submitted version.

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CRedit authorship contribution statement

Amy E. Peden: Writing – review & editing, Writing – original draft, Visualization, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Kyra Hamilton:** Writing – review & editing,

Writing – original draft, Methodology, Conceptualization.

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.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jsr.2024.06.008>.

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