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How will the public respond to in-vehicle fatigue detection technology?

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ABSTRACT

Fatigue detection technology (FDT) uses physiological, behavioural and/or performance data to detect and mitigate fatigue-related risks, typically in drivers. As an emerging technology, its application has tended to concentrate on the organisational and industrial context of professional driving. However, FDT is evolving towards general consumer vehicle integration, and understanding how the public may react to it is important for identifying potential issues and ensuring its design enhances road safety in both concept and practice. Six semi-structured focus groups were conducted with Australian road users (n = 23) to understand factors impacting FDT acceptance and uptake, in addition to identifying potential implications for policy and practice. Thematic analysis identified a total of 10 factors across the individual and broader system levels. Findings suggest that the public has ambivalence towards FDT, holding strong positive and negative views. While firm beliefs were held about the potential safety benefits of FDT, individual-level challenges associated with data privacy, the everyday user experience, and accuracy of the technology were identified. Moreover, system-level factors, such as the regulatory landscape and built environment were seen as potentially impacting acceptance and uptake. Notably, many of the beliefs held may not wholly reflect the capabilities of the technology or regulatory practices. Regulatory agencies may need to consider public education about the usage and capabilities of FDT for it to be accepted by consumers, in addition to establishing clear guidance and regulation around use.

1. Introduction

Estimates indicate that approximately 20% of vehicle crashes in Australia are, at least in part, caused by fatigue (Thomas et al., 2021). Similar rates have been reported internationally, with up to 25% of crashes in Germany (Wei, 2010), 17.6% of fatal vehicle crashes in the United States (Tefft, 2024), and 20% of vehicle crashes in the United Kingdom (Royal Society for the Prevention of Accidents, 2024) attributed to fatigue. These crashes generally occur due to the physiological and psychological consequences of fatigue, which includes diminished situational awareness, poor response times, compromised decision-making, and occurrences of microsleeps (Philip et al., 2005). Importantly, crashes causally attributed to fatigue tend to be more severe, particularly where the driver has fallen asleep at the wheel (Tavakoli Kashani et al., 2022), and as a result, more likely to result in fatalities. Fatigue can be defined as “a physiological state of reduced mental or physical performance capability resulting from sleep loss, extended wakefulness, circadian phase, and/or workload (mental and/or physical activity) that can impair a person’s alertness and ability to perform safety related operational duties” (International Air Transport Association & International Civil Aviation Organization, 2015).

To mitigate fatigue-related risk in vehicle crashes, many jurisdictions have included fatigue as a key target area within road safety policy (Commonwealth of Australia, 2018; Government of South Australia, 2023), invested in public education campaigns (Adamos et al., 2013; Fletcher et al., 2005), and looked towards technological solutions (Abbas et al., 2020; Doudou et al., 2020; Munala et al., 2012; Noyce et al., 2004). Policy and educational strategies broadly aim to keep fatigued drivers off the road, with slogans such as “Stop, Sip, Sleep” (Transpoco Telematics, 2015) and “A break every 2 h could save your life” (South Australian Police, 2024) used to notify the public of elevated fatigue-related risk. Similarly, policy approaches tend to focus on deterrence (e.g., fines) and behaviour change (e.g., increasing frequency of breaks). In contrast, technological solutions use the built or technological environment for near miss/crash prevention in situations where a driver is experiencing fatigue behind the wheel—ostensibly where educational and/or policy approaches have not led to the desired change in behaviour. Over recent decades, technological solutions have included audio tactile line markings (“rumble strips”), rest areas, and physical barriers. However, technologies designed to identify signs of driver fatigue and mitigate risk of crashes before they occur are now being developed and deployed (Cori et al., 2021). These technologies are broadly categorised Fatigue Detection Technology (FDT) or Fatigue and Distraction Detection Technology (FDDT) (Higginson et al., 2019), but also known as Drowsiness Detection, Driver State Sensing, or Driver Monitoring systems. These systems employ an array of detection techniques, including performance metrics (e.g., speed variation, lane deviation, harsh braking), and physiological indicators (e.g., heart rate variability, brain activity, eye movements) alongside camera-based monitoring to capture event footage (Cori et al., 2021). Inherent to all

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current FDT is the provision of 'alerts' to the user, with the aim of reducing the likelihood of a fatigue-related vehicle crash or other incident (Sikander et al., 2018). Recent data suggests that FDT employing 'drowsiness detection/warnings' has potential to prevent >55% of fatigue-related crashes (Thompson & Wundersitz, 2023).

While much of the literature to date has been focused on the technical aspects of FDT (e.g., reliability, validity, functionality) (Abbas et al., 2020; Cori et al., 2021; Mulhall et al., 2023), emerging alongside the technology itself is a growing body of work on the uptake and usability of FDT (Higginson et al., 2019; Nandavar et al., 2023). To date, this has focused on drivers who use FDT occupationally, which also comprises the vast majority of current FDT users. However, there is significant potential for FDT to be integrated into new private vehicle models in the near future (Arakawa, 2021). Indeed, several major vehicle manufacturers now include FDT as standard in late model vehicles. For example, vehicle manufacturer DS Automobiles now integrate the 'DS Driver Attention Monitoring' system, which incorporates a driver-facing camera with continuous vehicle position monitoring into all new vehicles (DS Automobiles, 2024). Similarly, Cadillac vehicles now include a driver-facing camera as part of their GM 2018 Cadillac CT6 Super Cruise System, which is designed to detect fatigue (Cadillac, 2018). Other vehicle manufacturers have similar systems that provide 'fatigue alerts' based on a range of behavioural, physiological, and driving inputs. These advancements have in part provoked new European Union regulations requiring all new vehicles to be fitted with a form of FDT as of 2022 (The European Parliament and the Council of the European Union, 2019). As a result, it is likely that in other jurisdictions, including Australia, we are also likely to see significant increases in vehicle manufacturers fitting new vehicles with FDT. The integration of FDT into private vehicles would ideally significantly enhance public safety, and offer a proactive measure against the global incidence (1.3 million fatalities annually; World Health Organisation (World Health Organisation, 2022)) of vehicle crashes and fatalities. However, the potential success of FDT, and the degree to which the technology positively influences behaviour, will likely be impacted by the experiences and perceptions of users (Davis, 1993).

A range of factors are likely to have a strong impact on whether an individual is willing to accept, adopt, and appropriately use a novel and unfamiliar technology. While no evidence is available to the authors' knowledge on what impact such factors may have on the acceptance and uptake of FDT, there is a wealth of knowledge from other technological domains, including AI (Kelly et al., 2023), telemedicine (Garavand et al., 2022), and smartphone-based technology (e.g., on-demand services, apps) (Min et al., 2021). It is apparent that negative perceptions, regardless of their accuracy, are strongly related to these outcomes (Garavand et al., 2022; Kelly et al., 2023; Min et al., 2021). In the case of autonomous vehicles—a domain with features arguably similar to FDT—a range of factors are likely to directly influence whether an individual is likely to choose to use such a vehicle (Dichabeng et al., 2021). Factors likely to impact acceptance and uptake of the technology broadly relate to both individual- and system-level benefits that potential users believe will occur. Abstract societal benefit (e.g., safety improvements, reduced traffic congestion in the case of autonomous vehicles) may not be sufficient for acceptance and uptake (Dichabeng et al., 2021). Similarly, many factors, including usability, trust, external conditions, and usefulness, may impact resistance to a technology (Kamal et al., 2020; Naweed et al., 2018), and even at times sabotage in situations where (like FDT) it may be unavoidable to use the technology (Cappuccio et al., 2023) (e.g., if a specific piece of software or smartphone application must be used to access healthcare (Kamal et al., 2020), or in this case, if FDT comes pre-installed in a vehicle).

When considering potential factors that may impact public acceptance of FDT, we can look to the advent of other novel technologies that have been developed and implemented in recent years. The Technology Acceptance Model (TAM) (Davis et al., 1989) is a common framework used to evaluate such factors that has found widespread application. The TAM has been used to frame acceptance and uptake of similar technology, including the likely acceptance of fully and partially autonomous vehicles (Chen et al., 2023; Koul et al., 2018), virtual reality technologies (Sagnier et al., 2020), and financial technology (Singh et al., 2020). Key elements of this model include the perceived usefulness of the technology, perceived ease of use, behavioural intentions to use the technology, and the impact of external or system-level factors (e.g., organisational or systemic contexts). While the TAM has not been applied to FDT, it is likely that the key factors identified in the model will inform public acceptance and uptake of this technology, much like other novel technologies.

Failure to address public perceptions of emerging technologies carries potential for adverse consequences and widespread rejection of the technology (Klein et al., 2020). Therefore, it is critical to understand and navigate the factors likely to impact acceptance and uptake of emerging technologies. This may help avert potential backlash but also ensure that FDT has the best chance of positively impacting road safety. Therefore, the research questions addressed by this study are.

RQ1. What factors are likely to influence public acceptance and uptake of FDT?

RQ2. What are the implications for policy and practice?

2. Methods

2.1. Study design

This study employed a qualitative orientation and focus group methodology to collect data from road users on their views about FDT. This was selected to gather deep and personalised insights into the public's perception of FDT (Naweed et al., 2017a, 2017b). The research was grounded in the ontology of critical realism (Bhaskar, 2013), enabling us to posit that while FDT operates within an objective reality independent of individual perceptions, the ways in which FDT is understood and accepted by the public are shaped by social, cultural, and psychological factors. This ontology allows exploration of the tension between the actual capabilities of FDT and the socially constructed beliefs of road users, particularly in terms of its perceived risks and benefits. Epistemologically, the research adopted a constructivist approach (Guba et al., 1994), recognising that knowledge about FDT acceptance and uptake is co-created through subjective experiences and interactions of individuals. Through these philosophical perspectives, the study design illuminated both the objective realities of FDT integration into consumer vehicles and the social constructions shaping public attitudes.

2.2. Participants and recruitment

Inclusion criteria for the study included age (≥18 years old), ownership of a current driving license, and residency in Australia. Convenience and snowball sampling methods were used to recruit sufficient participants to achieve saturation (Clarke et al., 2013). Saturation was determined when no new themes or ideas were deemed to be emerging from focus groups. Recruitment occurred via social media, through existing researcher networks, and physical posters placed on university campus notice boards. The sampling process aimed to capture a diverse range of people living in Australia. Given that FDT is only recently emerging in the Australian private vehicle market, it is likely that within this target population, there would be limited prior experience with the technology. However, prior experience was not used as an inclusion or exclusion criteria. Potential participants expressed interest via following a link included in advertising materials. Upon following the link, participants were provided with an information sheet through an online expression of interest survey (Qualtrics, Provo, UT) explaining the purpose of the study. After reading the information sheet, participants provided electronic consent along with their age, phone number, email address, citizenship status, state and region of residence, employment information, and an indication of how many hours they drove per week on average. These data were used to screen against inclusion criteria, and participants who met the criteria were contacted and booked in to attend a focus group.

A total of 23 road users participated in this study (14 female; 35 ± 13 years; age range: 24–75 years), with focus groups including 3–6 participants (focus group 1 = 6 participants; focus group 2 = 3 participants; focus group 3 = 3 participants; focus group 4 = 3 participants; focus group 5 = 5 participants; focus group 6 = 3 participants). Participant country of birth included Australia (n = 16), Denmark (n = 1), New Zealand (n = 1), Colombia (n = 1), South Africa (n = 1), Papua New Guinea (n = 1), Ethiopia (n = 1), and Zimbabwe (n = 1). Participants lived in urban (n = 6), regional (n = 14), rural (n = 2), and remote (n = 1) locations across Queensland (n = 17), New South Wales (n = 3), South Australia (n = 2), and Western Australia (n = 1). On average, participants reported driving for 4.9 ± 6.2 h per week.

2.3. Procedure

Focus groups were undertaken via online videoconference (Zoom, San Jose, California), lasted ~88 min (±9.9 min), and transcribed with each participant assigned unique identifiers (i.e., ID tag made up of focus group and participant numbers) to ensure anonymity.

Focus group data were collected using a semi-structured approach. As shown in Table 1, most questions were open-ended; this was to elicit perspectives, attitudes, and personal feelings about potential use of FDT, and encourage a comprehensive analysis. Participants were asked to describe their perspectives and attitudes about FDT, with a focus on how they felt personally about potentially using such technology.

Focus groups covered: introduction to FDT; relationships with fatigue; feelings about FDT; concerns about FDT; potential benefits of FDT; barriers to using FDT, and how FDT could be improved. Participation was compensated via an AU$50 Prezzee Smart e-gift card honorarium. The protocol was piloted and refined before use. Ethical approval was provided by the institutional Human Research Ethics Committee (Approval no: 2022-026).

2.4. Data analysis

Focus group data were thematically analysed to identify themes through open and axial coding (Braun et al., 2006). The first process of the thematic analysis was to transcribe the data and organise it orthographically. The transcription phase was then followed by the three stages of thematic analysis: immersion, coding, and categorisation of the data (Naweed, 2017a, 2017b; Naweed, Bowditch, Trigg, & Unsworth, 2020). In the immersion process, data were read line by line, and conceptual memos were made in reference to the research questions to capture ideas. Data were organised based on the similarity to other data in the focus groups and analysed inductively, meaning that all codes emerged through analysis (i.e., no a-priori code formulation). Initial codes were refined into central themes. NVivo (version 14.23.2) was used for initial open data coding and to assist with taking notes and visualising the data to answer the research question (NVivo, 2023). Each transcript from the focus groups was double-checked against identified codes systematically to ensure consistency, with repeated checks of understanding to verify accurate representation of coded data.

During analysis, one or two researchers led/co-led analysis, but in each step, coding and refinement occurred through continuous engagement in mutual reflexive dialogue and consensus seeking. This ensured a common understanding of the concepts/theoretical framework underpinning the study during the coding process, and consistency in coding decisions (Møller et al., 2022). Under the TAM, factors impacting technology acceptance can be broadly categorised as being at the personal/individual level or at a broader system level. The TAM was therefore used as a framework to interpret findings following the development of initial themes.

Table 1
Semi-structured interview protocol for the focus groups.

Topics	Example Questions
Introduction	What is FDT?
Ice breaker activity	If you could choose one word to describe your relationship with fatigue, how would you describe it?
Experiences with FDT	Have you heard of Fatigue Detection Technology? What experience have you had with fatigue detection technology?
Concerns about, and potential benefits of FDT	How concerned are you about fatigue-related accidents on the road? What are your concerns, and why do you have those concerns?
Barriers to FDT use and uptake	Any potential drawbacks or limitations of Fatigue Detection Technology that could affect its acceptance?

Note: this demonstrates the overview of the semi-structured protocol for each focus group.

3. Results

In line with the TAM, thematic analysis identified themes that fell into different groupings: factors influencing acceptance and uptake of FDT at the *individual-level* and the *system-level*. The next sections present the factors in two sections based on these groupings in turn.

3.1. Individual-level factors influencing acceptance and uptake of FDT

Six individual-level themes were identified based on a total of 540 coded references: (1) Positive reinforcement, (2) Operational accuracy of technology, (3) Personal autonomy and control, (4) User experience and functionality, (5) Scepticism and distrust, and (6) Target users. Themes, along with aligned factors and concepts discussed in focus groups can be seen in Table 2 (Pabel et al., 2022).

3.1.1. Positive reinforcement

Most participants highlighted that FDT could be helpful for detecting fatigue and expressed a willingness to engage with such technology. Existing beliefs about the perceived safety benefits of FDT, for example, were an enabling factor: *"[FDT is] a good thing. It's for the safety of everyone on the road"* (FG5P1). The inclination to use FDT in order to remain safe arose because of lived experience with fatigue, FDT, or other similar technologies. For example, in the case of a brand of FDT that was integrated with the vehicle:

> I actually didn't know our car had it, till I was driving one night and I kind of had a microsleep. It kind of pulled me straight … that was my experience with it. It probably did save my life (FG3P3).

Participants also reported positive experiences with other driver assistance technologies, such as lane assist, and pre-collision technology. Based on their experiences, participants indicated that while technology may not always function correctly, it was more beneficial to have it than forgo it: *"Yeah, I definitely [would] use [FDT]. Just nice to have it there as an extra safety feature"* (FG1P2). Some drivers had no prior experience with FDT but expressed a strong desire to trial it and experience its functionality firsthand before committing to using it in their own vehicle: *"I'd want to be able to trial and use it and think, is this useful or not?"*(FG5P5).

3.1.2. Operational accuracy of technology

Participants discussed an unwillingness to use FDT if it was not reliable (i.e., functioning correctly) and/or valid (i.e., being able to correctly identify when the driver is or is not experiencing fatigue). For participants, the concepts of reliability and validity intersected, coming together to form what they termed *"accuracy"* (FG5P5). FDT was seen to

Table 2
Individual-level themes, factors, and concepts affecting public perceptions of FDT.

Theme(s)[a]	Factor(s)	Concept(s) discussed in focus groups
Positive reinforcement, 13.7% (74)	Readiness to engage	Acceptance of new technology
	Existing beliefs about safety benefits	Crash prevention capabilities Feeling safer on the road
	Acceptance shaped by lived experience	Previous experience with FDT Previous experience with lane deviation technology Desire for a personal experience
Operational accuracy of technology, 9.8% (53)	Potential reliability issues	Technology breakdown Overly complicated design
	Trust in accuracy and validity of technology	Effectiveness of fatigue detection capabilities Potential for false positives Variability in detection accuracy between devices Need for scientific evidence and validation
Personal autonomy and control, 28.1% (152)	Loss of autonomy and choice	Reduced personal control over driving behaviours and decisions Restriction of personal freedoms and choice Autonomy in technology selection and uptake Ethical and moral implications
	Overreliance on technology	Risk of overreliance by drivers FDT is reactive rather than proactive FDT should be a last resort
	Privacy and data protection concerns	Cybersecurity Data storage and privacy 'Big Brother' dynamics
User experience and functionality, 25.9% (140)	Inappropriate or inadequate responses to alerts	Annoyance and inconvenience associated with frequent alerts Alert response strategies Intentional tampering and sabotage
	Critical functionality requirements	Optimal FDT features and characteristics Perceived current limitations of FDT Individual differences and customisation
	Seamless integration and simple design	Intrusiveness Integration with the vehicle and other technology FDT as a standard vehicle feature Design and aesthetics
	Poor safety outcomes	Potential for the introduction of additional hazards Unintended driver distraction
Scepticism and distrust, 15.5% (84)	Lack of trust and uncertainty	Distrust in artificial intelligence and other technical capabilities Distrust in user reviews
Target users, 6.85 (37)	Disproportionate impact of FDT on specific populations	FDT as a barrier to attending work Disproportionate impact on individuals with lower socio-economic status
	Certain populations may benefit more than others from using FDT	FDT is essential for heavy vehicle drivers FDT may work differently in regional versus metropolitan locations FDT may not work well for people with certain facial features FDT may not work well for people with disabilities or medical conditions People who experience high levels of fatigue may significantly benefit from FDT Inexperienced drivers need the type of support FDT can provide Older people may struggle to adapt to new technology

[a] Note: Shows percentage representation of data for all themes at the individual-level including number of coded references in parentheses.

have an inherent complexity which tended to be interpreted negatively, for example, one participant said *"a simple approach could be just what's needed"* rather than the *"bells and whistles"* they believed FDT would come with (FG6P1). Most participants believed that false positives would be a significant problem:

> I just think if [the FDT] was going off and it wasn't actually accurate, you know, that would be annoying. And you wouldn't rely on it or trust it anymore - I think that's the risk (FG5P5).

Concerns about validity also stemmed from perceived difficulties of having a standardised measurement to *detect* actual fatigue. Numerous focus groups raised discussion about some drivers not showing physical symptoms of fatigue despite being tired, and others displaying physical symptoms of fatigue but without feeling fatigued: "*Some people can be exhausted [and] not even look tired at all. Is the technology going to … be enough*" (FG2P3). Some types of FDT were considered to more likely be accurate than others, however only three participants indicated that they would want scientific evidence to be available to provide confidence in the validity of the technology.

3.1.3. Personal autonomy and control

Some focus groups discussed a concern about losing autonomy and control (i.e., personal choice) with use of FDT. It was thought that FDT could pave the way for the government or for their organisations to eventually take control their vehicles remotely and prevent them from driving were fatigue to be detected. The notion of FDT impinging on 'freedom' was thus a key point; participants debated whether improving road safety for all was worth placing restrictions on when a fatigued driver could drive, or if this was going a step too far. The ethics and morality was therefore called into question:

> When can the government or other authorities restrict my freedom in order to preserve the common good? There are all those sorts of moral implications of technology (FG3P1).

The ability for people to choose which type or brand of FDT they could use was considered to influence community uptake of FDT. This extended to specific features or characteristics of the technology, including choice on alert feedback (e.g., notification type, type of audio) and other technology characteristics.

Some participants indicated that drivers would choose to drive while fatigued because they would rely on the technology to wake them if they fell asleep. Overreliance on FDT was therefore a key point for autonomy and control, and believed to create potential for crashes and near misses. This was particularly in cases where drivers were seen to no longer consider it their responsibility to ensure they were sufficiently alert to drive safely. Building a reliance on FDT was also thought to have the effect of overriding other fatigue management strategies, such as taking sufficient rest breaks during long drives.

The relationship between reactivity and proactivity of FDT was discussed, with the general view that identifying fatigue after the driver was fatigued rather than beforehand was a limitation. This was seen as problematic because of a belief that late intervention was less effective for preventing fatigue, and therefore, fatigue-related crashes. Despite this, interpretations of FDT as a 'last resort' was appreciated if all other countermeasures had failed:

> [FDT] is like an airbag. I'm not [going to] put my face into it … [and] get into an accident [just] because it is there. It is an absolute last resort and not something I am going to take more risks just because the technology exists in the car (sic; FG1P6)

All focus groups brought up data privacy and protection of personal information as factors influencing FDT acceptance and uptake. FDT was believed to collect sensitive driver data, such as video footage and driving performance, and possess inherent vulnerabilities to data breaches, leaving people exposed. Concern was also expressed about what data regulatory bodies or enforcement agencies could access. Data that could be interpreted as a person 'doing the wrong thing' (driving while knowingly fatigued), or including video footage, were primary concerns, especially if accessed externally regardless of intent. Many discussions used the metaphor of 'Big Brother,' particularly in relation to driver-facing cameras and similar technological options, drawing notions of an omniscient and dictatorial power gazing into their lives. The government or other external parties were suggested to be able to use FDT to keep track of people's behaviour or conversations: "*in theory, [FDT] can pick up private conversations without permission from the user … you know, being watched by Big Brother*" (FG3P2).

3.1.4. User experience and functionality

The experience of receiving alerts was discussed at length in all focus groups, and underscored by a strong belief that FDT alerts would be "*annoying*", and have the effect of eroding trust in the technology with drivers removing or turning it off altogether. Moreover, some thought that if drivers did not know how to respond to alerts, or could choose not to act following an alert, there would be no value to FDT. Some felt that competing needs could override alerts: "*I already know I'm fatigued, and if I have somewhere to go, I'm probably not really gonna listen to it, like that's just honest truth*" (FG6P1).

Despite a lack of experience with FDT, some participants held beliefs and corresponding attitudes that FDT was underdeveloped, and would only use it if it were improved. This attitude was perhaps tied to the novelty of the technology; one participant, for example, noted that FDT should expand its remit and detect more than just fatigue, as "*fatigue is just one problem that we have to face when it comes to drivers' safety and behaviour*" (FG2P1). This resonated with extensive discussions about customising and personalising FDT. Some wanted it to be calibrated to their own signs and symptoms of fatigue:

> [I'd] have my [FDT] be specific to me. Pick up my trends, or when I get fatigued. Am I blinking too much? Am I yawning too much? For me? (FG3P3).

In addition to customisations, participants described innovating FDT so that it could change the vehicle climate or intelligently emit alerts, for example: "*I'd want it to be a tone that doesn't freak me out and give me like a heart attack when I'm driving*" (FG4P3). The relative merits of in-vehicle cameras in comparison to other types of FDT (e.g., wearables) were discussed and debated in terms of austerity. For example, one suggestion was that, rather than inside the vehicle, fatigue should be detected by roadside cameras and lead to police action/fines to provoke a deterrence effect similar to speeding.

A highly sophisticated FDT design was thought to be problematic if it made the FDT challenging to use while driving. For example, several participants indicated that if FDT notifications were shown on the vehicle dashboard, it may distract those attempting to respond (e.g., trying to find a specific button on the steering wheel). There was also a belief that FDT should be designed to be more seamlessly integrated with the driving environment:

> I would want the alert to come up on the heads-up display on the windscreen rather than on the dashboard because presently, I have got to take my eyes off the road to read the message (FG3P1).

For FDT to be user friendly, the prevalent view was that it would need to be both unintrusive and aesthetically pleasing but also that notifications should be sufficiently "*assertive*" to encourage safer behaviour on the road. Showing a fatigue detection alert on the dashboard alone was believed to not sufficiently improve driving behaviour (e.g., stopping to rest when fatigued).

Participants discussed the potential for FDT to introduce additional hazards and noted that this may inadvertently lead to poor safety outcomes. For example, if the driver displayed signs of fatigue, the warning, such as seat vibration or steering wheel nudges, could startle the driver, and lead to steering overcorrection. Similarly, many believed that FDT could distract drivers and increase the likelihood of a crash, particularly in contexts where vehicles have a number of existing alerts and alarms across other domains:

> They [could] be quite distracting … if you have all these different gadgets and things that make sounds and [are] saying different things, there's so many places where your eye could wander. That's not a good thing at all (FG2P1).

3.1.5. Scepticism and distrust

Distrust of information from new technology was a prevalent discussion point in focus groups, and often associated with commentary around AI. Several participants believed scepticism and distrust in the capabilities of FDT would be widespread, though others noted trust would increase as people grew more comfortable with the technology and gained confidence in the accuracy of FDT. A few indicated that they would not trust FDT to function as advertised, and many believed that it may actually cause vehicle crashes due to automated response to inaccurate readings.

> I made a decision … to swerved away from [an] accident … I was able to make that decision in a split second. But the AI would only be programmed to do one or the other, it won't be able to weigh up the pros and cons (FG2P2).

FDT was suggested to potentially misinterpret driver behaviour (i.e., avoiding a potential road obstacle as a sign of fatigue), and take control, which would result in other issues.

One focus group had a spirted debate about others' experiences of FDTs, with most not trusting user reviews when deciding whether or not to use FDT. A minority thought that user reviews may make them more likely to use the technology, particularly if testimonials came from people they knew: "*I'd probably wait for a friend to get something and then try that out*" (FG5P5).

3.1.6. Target users

The potential for FDT to have greater negative consequences for specific populations was a large point of discussion. One focus group discussed the deontology of FDT limiting their ability to get to and from work, believing that the legal consequences of driving with detectable levels of fatigue would impact this. The prominent belief was that, unlike the decision to drive while impaired for another reason (e.g., alcohol or illicit drugs), the decision to drive while fatigued was often beyond the control of the individual. Many held the belief that people should not be penalised for circumstances beyond their control, such as family responsibilities, extended commutes, and shift work. Concerns were also raised around disproportionate impact to people with lower socioeconomic status:

The people who were more impacted by some threat to their [driving] license are the ones that live with a 90-minute commute, not a half hour commute. They were the ones that couldn't just work from home. Now that they couldn't drive. They're gonna be the ones that are working annoying shifts. They're gonna be the ones doing two casual jobs who are more likely to be detected as fatigued … [FDT] could be a big sociopolitical issue (FG3P1).

Some participants believed that certain groups would be more or less willing or able to use FDT. FDT was believed to be useful for those who had to drive long distances as part of their employment, but they stopped short of believing it would also be useful for themselves:

I like the idea of truck drivers using it … a signal to their manager who can give him a quick call, or, you know, over the radio and just be like, 'hey, mate, are you okay?' Would you like to pull over? We have got an [alert] that I agree with. But my personal use probably would not be too beneficial (FG5P1).

Some believed that FDT may have most utility for regional or rural locations, rather than metropolitan. The view was that FDT would work better when undertaking long distance driving than city driving, where driver behaviours would involve more movement (e.g., merging, changing lanes).

It was also suggested that FDT would struggle to detect fatigue in populations with specific physical features. The general attitude here was that FDT should be customisable for people with a range of physical characteristics, and inclusive for people with physical disabilities. This level of customisation was perceived to be critical to ensure that the technology could be effective for everyone. Despite this, particular emphasis was placed on populations more likely to be exposed to high levels of fatigue. Shift workers and new parents were considered to be at greater risk of a fatigue-related vehicle crash, therefore thought to be more likely to see safety benefit from using FDT. One participant described strong feelings about the use of FDT in young or inexperienced drivers, suggesting that parents would feel much safer if their teenage children had FDT installed:

I have a daughter who's about 17 and got her provisional license. That's a whole other lever level of terrifying to me … I'm really concerned about her safety on the road … So I think especially for inexperienced drivers, it could be really handy for them, and I'd get it for her. (FG5P5)

However, not all community members were believed to readily accept FDT, particularly older populations, or those accustomed to driving vehicles without sophisticated technology.

3.2. System-level factors influencing acceptance and uptake of FDT

Four system-level themes were identified based on a total of 183 coded references: (1) Insufficient infrastructure and cost, (2) Legal considerations, (3) Regulation, and (4) Education and training. Themes, along with aligned factors and concepts discussed in focus groups can be seen in Table 3 (Pabel et al., 2022).

3.2.1. Insufficient infrastructure and cost

Focus group discussions displayed a belief that the cost of FDT might limit improvements to community road safety, particularly if it were inaccessible to a large proportion of the population. The general assumption was that FDT would, by its nature, be cost prohibitive to buy, regardless of whether devices were purchased aftermarket (and installed into/used while driving existing vehicles) or if they came as standard with new vehicles. Addition of FDT into vehicles was considered to increase purchase price, rendering the vehicle more out of reach:

Every time you add more technology, [it's] gonna add more money to the cost of the vehicle. So are people going to be able to pay for it?" (FG6P1).

Table 3
System-level themes, factors, and concepts affecting public perceptions of FDT.

Theme(s)	Factor(s)	Concept(s) discussed in focus groups
Insufficient infrastructure and cost, 45.9% (84)	Cost and affordability	FDT would be overly expensive Challenges associated with retrofitting
	External environment and safety concerns	Lack of adequate roadside rest areas and infrastructure Personal safety Large scale data use
Legal considerations, 15.8% (29)	Discoverability of data	Access to personal data by authorities
	FDT should be a friendly helper	Legal protections for FDT users
	Penalties and consequences	Legal penalties for driving with symptoms of fatigue Insufficient penalties for fatigued driving
Regulation, 13.6% (25)	Companies and individuals need guidance on how to use FDT	Ability of drivers to make decisions about whether they continue to drive Regulatory oversight is needed FDT use in organisational settings Use of FDT to assess fitness to work or drive
	Insurance implications	Impact of FDT data on insurance costs
Education and training, 24.5% (45)	Increased driver education	Need for fatigue management education for drivers Driver training on appropriate FDT use
	Best practices for FDT usage	FDT should be used as a learning tool FDT implementation

[1]Note: Shows percentage representation of data for all themes at the system-level including number of coded references in parentheses.

The general belief was that in new cars, FDT should already be integrated (i.e., before market) with no added cost, and that technology vendors and regulators should retrofit FDT into older vehicles. People of low socio-economic status and/or younger drivers were considered to find it challenging to afford FDT; several participants held a belief that younger drivers generally purchased cheaper, older cars, without high-quality safety technology.

Issues with infrastructure and driving environment were also considered to impact the willingness to use FDT. Use of FDT was imagined to mean that, at times, drivers would need to pull over mid-drive were fatigue were detected. As a result, an increased need for rest stops was discussed, particularly for long distance drives. This was raised as an issue because many believed that the current number of rest stops, and distances between them, would be insufficient if fatigue were detected by an FDT while driving. The concern was that FDT feedback may not have any real impact on driver behaviour, as drivers would simply have to keep driving. While this was primarily discussed in the context of long-distance driving, where most FDT alerts were believed to occur due to extended driving periods, discussion also noted a lack of safe rest areas as an issue in metropolitan locations:

… there needs to be places in the city where you can stop safely and rest because there isn't anywhere … [are] we going to go in the middle of Perth safely to nap in a McDonald's car park? Absolutely not. You know it's not safe. (FG2P2)

It was also believed that drivers would avoid stopping at night due to feeling unsafe. Not feeling safe on the road was discussed to stem from low signal/network connections, the *"scary"* setting of some stops, and because many rest stops were in isolated locations. These feelings were particularly pronounced in relation to using rest stops/other facilities at night, and for female participants, who said they would be unwilling to stop for a break or nap due to safety concerns: *"the idea of being by myself on the side of the road and actually having a rest … creates this vulnerability"* (FG4P3).

Digital infrastructure was also considered with one focus group discussing how large-scale use of FDT data could be used to identify fatigue 'hot spots' with government resourcing directed to support road safety. Population-level FDT data was imagined to ideally be *"integrated with civil infrastructure"* (FG4P1) to determine where it may be most appropriate to build additional rest stops. The potential for using FDT collected data in this manner—rather than solely as part of a driver-FDT feedback loop—was generally viewed as a positive.

3.2.2. Legal considerations

Concerns were expressed about the legal implications of FDT use, and the data collected by FDTs carrying legal implications for people. There was a general belief that enforcement agencies would penalise drivers for lack of compliance with rules associated with FDT use, and their data would be legally discoverable. For example, FDT would monitor peoples' habits, and record and keep their data, which would then be used as evidence to prosecute them. In relation to this, a popular scenario discussed was that of a driver ignoring FDT warnings and continued driving:

> Most people's concern would be, you know, how am I going to be more liable? Or charged? And is that data kept? And can that data be used against me? In a court of law, that might say … that that person showed signs of fatigue an hour before the crash. (FG4P1).

In conjunction with the individual-level factors on user experience and functionality, many believed that FDT should be a *"friendly helper"* with alerts supporting people to make better decisions, but that this information should not be available to the police or have legal implications even in an at-fault vehicle crash scenario: *"it would be safer if whatever information we want to keep is kept in a closed loop … or immediately deleted"* (FG3P2).

Despite apparent mixed feelings about the potential acceptability of FDT, most focus groups discussed the potential consequences of driving while fatigued at length, and generally felt that harsher deterrence may be required to improve driver behaviour. Many believed current deterrence strategies were not strong enough, regardless of whether FDT data could be incorporated into legal frameworks. Some believed that road safety could be improved by combining deterrents with FDT driver monitoring: *"people get off very lightly. And it just feels like we need to create some incentive for good behaviour on the road"* (FG4P2).

3.2.3. Regulation

Regulation was observed as a particularly important element in organisational and professional driving contexts, in cases where drivers used FDT in their work vehicles. A few focus groups discussed companies and individuals both needing guidance on how to use FDT and react to a fatigue alert. Debate focused on what actions would be appropriate in the event of an alert, including whether people should stop driving after the first alert, or whether there should be a graded approach to actions taken post-alert. The concern was that specific actions would be required if an alert occurred, regardless of whether it was a 'false positive' (i.e., when the driver was not actually fatigued). However, ambivalence was expressed about whether drivers should, or indeed could, be trusted to evaluate their own fatigue in this scenario. The main view was that in work contexts, drivers should be permitted to stop driving if an FDT alert occurred, or if they believed they were not sufficiently alert to drive safely, with FDT data used by the workers themselves to "prove" to their employers that they were too fatigued to continue: *"[FDT] could be used as sort of evidence to say, look, I couldn't push on because the technology kicked in"* (FG1P2).

A general belief was that FDT would need to be regulated, including regulations to ensure it functioned as intended, and to ensure appropriate organisational use: "*I think it needs to be carefully regulated … It couldn't just be used recklessly*" (FG3P1). It was noted that FDT could be used by organisations to establish whether a professional driver was fit to work. Lastly potential insurance implications of FDT use were discussed, with some believing that information collected via FDT would impact insurance premiums and whether this meant that claims would be paid out:

> The insurance company can ask you if you have had the technology before … [and] if you get a score … that might determine how much you have to pay [for] your insurance cover (FG4P2).

3.2.4. Education and training

Discussion adopted a general view that drivers needed more education about fatigue, and how to manage its risks, regardless of whether or not FDT was in use. For some, limited deterrence value was believed to be had with punitive measures (e.g., fines) than with education, which was expected to lead to greater behavioural change. Limitations of current driver training practices were also perceived and questioned *"if we're really educating younger people when they get their licenses"* (FG5P5). Some indicated that while FDT may be useful, their own preference would be to support additional driver training rather than relying on technology; however, if FDT was used, the strong consensus was to appropriately train and educate people on how to use FDT with information on how the technology itself functioned and on what to do when alerts occurred.

The potential for FDT as a learning tool to support driver behaviour was discussed. Some indicated that while FDT may not be able to "force" people to behave in a certain way (e.g., stop driving), the information it provided could still be a valuable feedback loop to improve their behaviours. Discussion points included helping individuals to become more aware of their own signs and symptoms of fatigue while driving to reduce the number of alerts (and therefore amount of time spent driving with a high level of fatigue) over time.

Lastly, several participants discussed how the widespread roll out of FDT could be perceived by the public, and generally believed that educating drivers about FDT, including targeted advertisements and marketing, would help gain public acceptance. There was the sense that if appropriate education was not provided, public backlash and rejection would ensue, particularly in relation to types of FDT that incorporates in-vehicle cameras:

> It comes down to effective marketing and consistent messaging … so [they have an] understanding of what the fatigue detection technology does and why it's actually there. (FG1P2)

4. Discussion

This study aimed to understand the factors likely to influence public acceptance and uptake of FDT (RQ1) and the implications of this for policy and practice around consumer use (RQ2). A large number and range of individual- and system-level factors were identified, with beliefs and attitudes showing ambivalence toward FDT, its benefits, drawbacks and challenges. Factors associated with the individual and FDT itself (e.g., accuracy, user experience) would practically impact day-to-day acceptance and functionality, while system-level factors shed light on the broader regulatory and legal landscape occupied by this type of technology. Fig. 1 integrates all of the themes identified in the study, depicting those at the individual-level in the form a Venn diagram to illustrate potential overlapping relationships, and those at the system-level as a layering of outer concentric rings, broadly depicting hierarchies in the relationships exuding from outward (regulation, legal considerations) to inward (education and training). All of the identified factors in the Venn (i.e., the individual-level factors) overlap, illustrating that the various intersections with one another may compound and

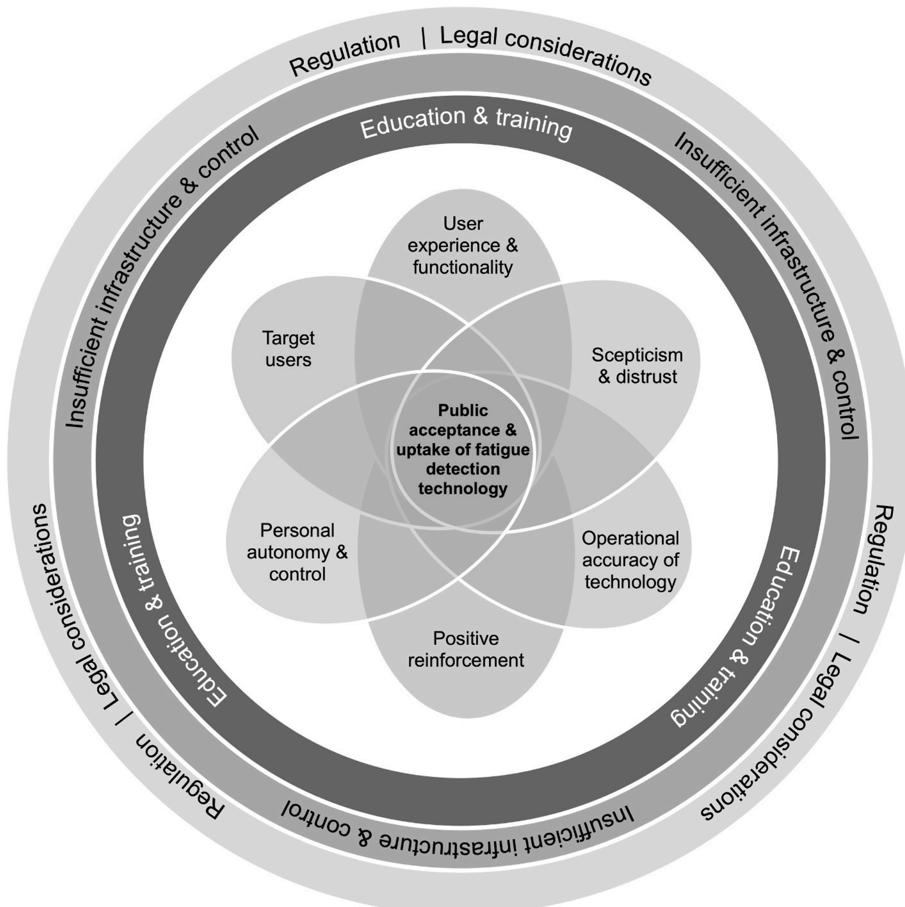

Fig. 1. Themes influencing public acceptance and uptake of FDT Systems at the individual-level (inner Venn diagram) and the system-level (outer concentric rings).

multiply to influence acceptance and uptake of FDT for an individual person. The inner Venn and concentric circles (representing system-level factors) convey the main relationships established via our analysis, which is between-level (i.e., the individual level and the system level).

The factors identified to potentially impact the usability and acceptance of FDT align closely with the TAM theoretical framework and helps us to understand it in the context of existing knowledge around technology acceptance. It is apparent that factors impacting the acceptance of other technologies (e.g., autonomous vehicles), which align with the TAM, may similarly impact acceptance of FDT. Therefore, the TAM seems to be a suitable model for understanding FDT acceptance. The application of the TAM to the FDT context is a clear novel contribution of the present study, which has been the first to undertake a qualitative investigation of public attitudes towards FDT. This study therefore represents both a strong theoretical and methodological contribution to the FDT literature. For Australian road users, individual-level factors strongly aligned with those expected under the TAM (i.e., perceived usefulness and ease of use). Positive sentiment was shared regarding potential safety benefits of FDT (i.e., usefulness) and the belief that FDT would be easy to interact with (i.e., ease of use). Conversely, problems with either of these were associated with negative perspectives. Specifically, if FDT was not accurate or resulted in negative outcomes for the driver (i.e., low perceived usefulness), there was less acceptance and intention to use the technology. Similarly, technological complexity and operational difficulties could be considered evidence of poor 'ease of use' – and were similarly associated with poor acceptance.

Under the TAM, external or system-level factors are also considered an important contributing factor towards technology uptake and use. The findings of the present study strongly indicate that such factors, including infrastructure, education, and the regulatory/legal context, would likely play a large role in FDT uptake and usability. As a result, it appears that the TAM could be used to model future acceptance and uptake of FDT. This aligns with the applicability of the TAM to user acceptance and uptake of similar technology, such as autonomous vehicles (Panagiotopoulos et al., 2018; Wu et al., 2019), wearable fatigue monitoring technology (Strong, 2020), and smartphone-based driver assistance systems (Voinea et al., 2020), where usefulness, ease of use, and environmental/systemic factors are strong predictors of intention to use. Strong beliefs about the potential safety benefits of FDT for managing driver fatigue—a perennial problem—were shared, even as these were balanced by equally strong concerns. The latter ranged from ethical considerations around the impact of FDT on vulnerable groups, to issues around personal choice, data privacy, and legal implications. This ambivalence reflected sentiments from the public around analogous emerging technologies, including autonomous vehicles (Kacperski et al., 2021), robots (Dang et al., 2021), digital health interventions (Marent et al., 2018), and new energy vehicles (Zhang et al., 2023). Attitudinal ambivalence, characterised by an individual holding concurrent positive and negative feelings (Thompson et al., 2014), may be a logical response to theoretical future scenarios with which the individual has limited prior experience. In the present study, nearly all who took part had no prior experience with FDT, and while a small number did, ambivalent responses were common across both. Technology is often associated with a disconnect between beliefs and actions (Barth et al., 2019), for example, many social media users claim to have strong concerns about data privacy and data sharing, but continue to both use social media platforms and share their personal information online (Hargittai et al., 2016). Such a response may also occur with FDT engagement (particularly if they come as standard in new vehicles), despite holding negative feelings. In view of this, protecting personal data, and clearly communicating what protections are in place, may be paramount before introducing the technology to the public.

A range of beliefs were held about how driving performance may be impacted by FDT, both positively and negatively, and included potential new hazards (e.g., distraction or over-reliance). Beliefs were also held regarding the potential for FDT to accurately assess fatigue in all individuals, when there are individual differences in the development of signs and symptoms of fatigue. It is possible that such beliefs may impact driver behaviour, both in terms of their willingness to use FDT, and in their trust in alerts when they do occur. In addition, while many participants believed FDT would be useful with indications that they would be likely to accept such technology, it is unclear whether this would necessarily lead to behaviour change. That is, simply having FDT in a vehicle does not necessarily mean that driving behaviour, or fatigue management strategies used by drivers (e.g., breaks), would be improved. Moreover, behaviour change caused by FDT may be unpredictable, and not necessarily positive. For example, it is possible that FDT use may result in overreliance and an increased willingness to drive while fatigued. In our view, strong public education, including what actions could be taken in response to FDT alerts, alongside FDT rollout, would be critical to support appropriate behaviour change.

Concerns were also raised about potential consequences of FDT, in cases where drivers felt (correctly or incorrectly) that they would not be able to drive. This may be more problematic for some socio-demographic groups over others. Such concerns should not be dismissed; for any novel technology, unintended consequences risk damaging effects for users or the community more broadly (Rosenbaum et al., 2022). For FDT specifically, experiences of technology roll out among certain user groups (i.e., professional driving populations) cannot be directly transposed to the general public, due to great differences in demographic factors, driving experience, vehicle type, training and education, and organisational safety systems (Mooren et al., 2014; Short, 2014). Therefore, we cannot assume to know what all consequences of FDT will be for the public. It will therefore be important for regulatory and enforcement bodies in addition to technology vendors, to monitor and track the direct impact of FDT among the public, and for future research to evaluate both the short- and long-term impacts of use. Additionally, FDT developers need to address the intended use of FDT, and highlight how it can be utilised to assist driving instead of resulting in complete reliance on the technology.

Legal and regulatory concerns with using FDT included penalties and loss of driving privileges, particularly in cases where drivers do not act in response to fatigue alerts. This aligns with evidence from the Australian road transport industry, and potential legal and privacy issues based on the commercial setting of FDT utilisation (Dawson et al., 2014). This has also been reflected in the perceptions and concerns of drivers in the road transport industry who have experience with FDT (Higginson et al., 2019). Similarly, in commercial settings, organisations may face legal problems based on either the type of FDT they select, or how they choose to use that FDT (Dawson et al., 2014). A recent legal case resulted in the prosecution of a road transport operator because they had FDT installed, but did not take any action after >400 field-of-view error alerts occurred over a two-month period (De Vaney, 2022). Substantive concerns raised in the present study may thus not be entirely unfounded, and it may be prudent for FDT developers and regulators to ensure greater transparency around the technology's intended use (e.g., what actions are required when alerts/error message occur) for members of the public, including clarity around potential legal ramifications.

The concerns about the intersectionality between FDT and road infrastructure (e.g., necessitating frequent rest stops in rural/remote areas, missing infrastructure) may be reasonable, particularly for those in regional areas where there can be limited opportunities for drivers to stop if fatigue is detected while they are driving (Bunn et al., 2019; Job et al., 2017; Meuleners et al., 2017). Moreover, delineation, lack of bitumen quality, and a lack of signage in rural areas may interfere with FDT effectiveness (Peiris et al., 2021). Such features of road infrastructure and the environment may interfere with the technology itself, including its capacity to accurately detect fatigue in drivers (e.g., due to limited connectivity or high levels of vibration/heat). Critically, road infrastructure must permit drivers to take appropriate action when alerts do occur. Where infrastructure components such as signage, road/shoulder width, availability of rest areas are poor, drivers may not be able to take breaks or engage in other fatigue management strategies when they need to. It is therefore not outside the realm of possibility that without adequate infrastructure, FDT may indeed not result in improved driving behaviour and overall road safety. Similarly, the interaction between FDT and other in-vehicle technologies (e.g., advanced driver assistance systems, lane keeping assistance, autonomous emergency braking) may be worth considering as FDT becomes more common. For example, in-vehicle environments that involve a range of technologies that provide alerts may increase the likelihood of 'alarm fatigue', where drivers are desensitised to alarms or alerts and therefore do not respond appropriately when they occur (Ayas et al., 2024). Similarly, a driving environment with too many alerts could result in annoyance in drivers – who may choose to deactivate or otherwise ignore the technology. It is likely that the effectiveness of FDT would be impacted (either positively or negatively) by either integration or competition with other technologies.

While a range of beliefs and perceptions about FDT were shared, many appeared to have a limited basis in clear evidence. The belief that FDT would autonomously exert control over the vehicle if fatigue were detected was an example that defied current technological designs. The vast majority of current FDTs simply provide auditory and/or haptic alerts, without any direct impacts on vehicle behaviour (Cori et al., 2021). The belief that FDT was 'good' but required improvement was interesting, but the basis for it was unclear given that it was generally reported by those with no existing personal experience or education around FDT. Other beliefs similarly had limited basis in either experience or established fact, including the view that fatigue manifested so variably that it this impacted the accuracy of FDT detection (Van Dongen et al., 2004, 2011; Åhsberg et al., 2000). The results reflect a range of personal experiences, opinions, and biases in perceptions of FDT. Given the novelty of FDT for many, it is arguably unsurprising that unsubstantiated beliefs were shared. That is, in the absence of public education and/or personal experience, beliefs developed without factual input. While many public beliefs may be inaccurate, these beliefs are still likely to shape behaviour (Crow et al., 2013). As a result, significant public education may be needed, particularly with regard to the technical capabilities of FDT, for it to be used safely and effectively.

4.1. Implications for regulation and policy on FDT use in public vehicles

This study highlights several critical factors for regulators and policymakers to consider as FDT becomes more prevalent in public vehicles (see Table 4). Data privacy and availability, including the potential for FDT data to be used for legal enforcement by policy, will need to be clarified and communicated to the public as part of any public education efforts. Moreover, safety and performance impacts of FDT use in private vehicle drivers could be monitored, in addition to identifying any unintended consequences or hazards produced by FDT use. For example, population-level crash data would ideally begin to incorporate information about any FDT inside vehicles involved in crashes. Similarly, FDT data could be evaluated at the population level to determine direct and indirect impacts (e.g., fatigue events detected, behaviour change in users). In addition to broad regulatory considerations, public education and driver training could potentially be used to inform the public about how to use FDT to improve their safety, and about what their legal obligations are when FDT is in use (e.g., what drivers are required to do when an alert occurs). It is critical to understand that FDT does not exist in a vacuum, but rather within a complex transportation ecosystem. Thus, assessment of road infrastructure needs have merit, particularly in rural and remote areas where it may not be safe to stop driving if fatigue

Table 4
Key policy implications and recommendations for FDT implementation.

Policy Implication	Key Recommendations
Data privacy	Develop specific regulations to secure FDT user data, ensuring protections for personal information and preventing misuse of collected data.
Legal status of FDT	Clarify the legal framework for 'fatigue alerts' and potential enforcement, specifying data access rights and any circumstances for using FDT data in legal contexts.
Safety and performance	Establish a monitoring system to assess FDT's safety impacts and identify potential hazards, adapting policies based on FDT's effects on driver behaviour and performance over time.
Public education	Launch awareness campaigns that explain FDT's technology, legal responsibilities for users, and potential implications, empowering drivers with knowledge.
Driver training and support	Implement training programs for drivers, especially commercial drivers, to help them understand and effectively respond to FDT alerts, fostering safer adoption of the technology.
Infrastructure requirements	Assess road infrastructure needs, especially in rural/remote areas, to facilitate safe driver responses to FDT alerts and ensure accessible rest areas.

were detected. Regulators will also need to consider how FDT may intersect with other vehicle automation systems, navigation technologies, and driver assistance features, ensuring a cohesive approach that promotes driver safety without compromising privacy or autonomy.

4.2. Strengths, limitations and future directions

This study contributes to an emerging but still small body of literature regarding FDT, and even less knowledge about factors impacting acceptance and uptake. It provides compelling insights into how the public may respond, however, some limitations must be considered when interpreting findings.

First, participants were all based in Australia, thus findings predominately reflect the perceptions of individuals based in this country. It was deemed important to undertake the study in just one jurisdiction in order to avoid potentially vast differences in regulation/legislation relating to FDT. Moreover, as FDT is not yet mandated in Australia, this context provides a unique opportunity to gain insight in a population with limited experience of FDT – but who will likely be exposed to it in the near future. Despite this, it would likely be beneficial for future research to target other populations internationally, to understand a more broad and generalisable perspective. Individual perspectives could potentially vary in jurisdictions where FDT has been in place for longer (e.g., Europe), or where there are very different legislative frameworks and enforcement around driving practices. The extended distances between major cities in Australia (and associated extended periods of time many individuals spend driving) may make the issue of fatigue more salient for populations in Australia, and those with similarly extended distances.

Second, the present study used a qualitative methodology, enabling in-depth discussion and collection of rich data simulating how some members of the public may react to FDT. This approach was a significant strength of the study, though the size of some smaller focus groups (e.g., three participants) was somewhat of a limitation. Small focus groups diminish the potential for ideas to be built on and develop between participants as part of group dynamics. Furthermore, the recruitment of participants from social media, on campus locations, and via existing networks, may have introduced some degree of sampling bias, potentially limiting representativeness. However, participants in the present study did represent a broad range of ages (24–75 years) and backgrounds, which is a significant strength. The study offers a series of factors for further research. This may be undertaken with a broader sample with the identified factors evaluated quantitively across a wider cross section of the population, and to understand the impact of different personal characteristics (e.g., age, gender, length of time holding a driver's license), to offer a more comprehensive understanding of potential public responses to FDT.

Finally, future research may address different types of FDT, which have different capabilities and features – in addition to potentially measuring slightly different constructs (e.g., fatigue, sleepiness, distraction). Future research would also ideally be undertaken to understand how to best leverage FDT to improve driver behaviour; one pathway could for this could be an evaluation of public education strategies.

4.3. Conclusion

FDT is likely to be present in the vast majority of new vehicles in the coming years, in Australia and beyond. To ensure that this technology achieves its intended positive safety outcomes, it is crucial to consider perspectives of its potential users. While the public may appreciate the potential safety benefits, the acceptance and appropriate use of FDT depend on addressing a range of both individual- and system-level factors. Ideally, both FDT manufacturers, and legislative/regulatory bodies would address usability and functionality concerns (e.g., accuracy), in addition to the broader context in which the technology operates. Critically, questions about legal implications and user privacy must be addressed to support the effective adoption of FDT. If these concerns are addressed, the potential safety benefits of FDT for the public could be significant.

CRediT authorship contribution statement

M. Sprajcer: Writing – review & editing, Writing – original draft, Supervision, Methodology, Investigation, Formal analysis, Conceptualization, Project administation, Validation. **M. Muchinguri:** Writing – original draft, Project administration, Investigation, Formal analysis, Data curation. **G.E. Vincent:** Writing – review & editing, Writing – original draft, Conceptualization. **A. Naweed:** Writing – review & editing, Visualization, Supervision, Methodology, Investigation, Formal analysis, Conceptualization, Writing – original draft, Validation.

Declaration of competing interest

None.

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Data availability

The data that has been used is confidential.

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