Simulators, driver education and disadvantaged groups: A scoping review

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Key Findings

- Simulators are a tool used to deliver driver education programs rather than being driver education in itself.
- There is no guidance within the literature regarding which driving skills should be targeted with the simulator, the length of this intervention or how it should be incorporated within programs for disadvantaged groups.
- A driver education program for indigenous populations that incorporates a driving simulator could not be found within the literature.
- There is a need for more research within this area.

Abstract

This paper examines simulators to deliver driver education programs for two very different populations (a) those who have specific impairments or intellectual disabilities and (b) those who may suffer disadvantage associated with their ethnicity. To do this we addressed two research questions (a) What role, if any, can simulation play as an education and/or training intervention for individuals disadvantaged because of individually-orientated concerns such as intellectual impairment or ADHD? (b) What role, if any, can simulation play as an education and/or training intervention for those who are disadvantaged because of their indigenous ethnicity? Technological developments have enabled the incorporation of driving simulators into driver education programs. A review of major databases using keywords identified 2,420 records. After duplicates were removed and screening occurred, thirteen studies were included in the review. The disadvantaged populations for the driver education initiatives that incorporated a simulator were very specific (e.g. intellectual disabilities) with no interventions for those disadvantaged because of ethnicity. A second search identified six papers that discussed interventions for indigenous populations. None of these interventions had a simulator component. The review highlights the need for high quality empirical research in the area of simulators, driver education and disadvantaged groups in order to inform policy development within this area. While there are some preliminary results indicating potential benefits, there is limited research evidence for an initiative of this type making it difficult

to develop evidence based policy and practice. Therefore, when these types of initiatives are introduced, they need to be evaluated.

Keywords

driver education and training, novice drivers, driver simulators, young drivers, teen drivers, indigenous

Introduction and literature review

Young drivers experience the highest rate of crashes when compared with all other age groups of drivers (Williams, 2003) with several reasons for this including inexperience, social and situational factors, exposure factors and attributes related to the young driver themselves such as demographic, personality and developmental factors (Bates, Davey, Watson, King & Armstrong, 2014; Shope, 2006). There are many types of disadvantage that may affect young people that would like to obtain a licence. There are disadvantages, such as intellectual impairment or attention-deficit-hyperactivity disorder (ADHD), that are more individually orientated. In contrast, there are people who are disadvantaged because of their association with ethnic minority groups. Evidence suggests that young drivers with ADHD (Curry, Yerys, Metzger, Carey, & Power, 2019; Jerome, Segal, & Habinski, 2006), a mental disability (Brooks, Mossey, Tyler, & Collins, 2014) or a member of minority ethnic group such as indigenous Australians (Cercarelli, 1994; Cercarelli & Knuiman, 2002; Clapham, Senserrick, Ivers, Lyford, & Stevenson, 2008), indigenous Canadians (Desapriya, Fujiwara, Verma, Babul, & Pike, 2011) and Maoris (Sargent et al., 2004) have an increased risk of crashing or other negative driving outcome.

A meta-analysis, that included studies conducted with samples of young drivers and drivers more broadly, identified that individuals with ADHD were 1.54 times more likely to experience a negative driving outcome. This included offences and as well as crashes (Jerome et al., 2006). A more recent study suggested that the risk of crashing for drivers with ADHD was lower at 1.23 times more likely once exposure was controlled for (Vaa, 2014). There appear to be a range of reasons for this increased risk including that drivers with this condition were more likely to be distracted while driving (Reimer, Mehler, D'Ambrosio, & Fried, 2010), engage in speeding behaviours (Vaa, 2014) and participate in unsafe driving behaviours more generally (Rosenbloom & Wultz, 2011).

Very little research in the field of driver education has been undertaken with individuals who have an intellectual disability since the 1970s (Brooks et al., 2014). It is therefore difficult to identify if these individuals have higher crash rates. Brooks et al. (2014) conducted exploratory research with four students aged in their early twenties who had intellectual disabilities (average IQ of 71.5). The results of their study were inconclusive with half of the participants demonstrating some improvement and half failing to demonstrate improvement.

As noted above, individuals from minority ethnic groups also have higher crash rates with indigenous Australians more likely to crash than non-Indigenous Australians (Clapham, Senserrick, Ivers, & Lyford, 2008) and indigenous Canadians more likely to crash when compared with the general population (Desapriya et al., 2011). Although, given that some jurisdictions such as New Zealand do not include ethnicity on traffic crash reports, it is sometimes difficult to identify if these groups are over-represented (Sargent et al., 2004) and the reasons for the over-representation. In these situations, it may be possible to obtain ethnicity information from other sources. For instance, Sargent et al. (2004) linked health records (which contained ethnicity) with police traffic reports in order to study the factors associated with fatal and non-fatal crashes that involve Maori. It is possible that some of the reasons for the over-representation of minority groups such as African-Americans are less likely to wear seatbelts than white Americans and they are more likely to drink and drive (Juarez, Schlundt, Goldzweig, & Stinson, 2006). Research suggests that Maori youth are unaware of the penalty regime for driving offences indicating that there is little deterrence effect of this measure (McDowell, Begg, Connor, & Broughton, 2011).

Driver education

One countermeasure aimed at reducing crash rates for novice drivers is driver education and training (Bates, Watson & King, 2006). Training refers to programs which aim to develop a person's skills required for driving. Education is a broader concept which may incorporate skills development but is also aims to provide other abilities that will enhance driving safety such as hazard perceptions skills (Langford, 2002). In order to increase young driver safety, driver education and training needs to address the various factors linked to crashes (Mayhew, 2007). In addition, individuals must be motivated to use what they have learnt and the education and training must be tailored to the group receiving it (Mayhew & Simpson, 2002). There are many different types of driver education and training including school-based driver training, resilience training, procedural skills training, hazard perception skills training and education, situation awareness training and insight training with research suggesting that effectiveness of each is varied (Beanland, Goode, Salmon, & Lenne, 2013).

The research evidence suggests that traditional, skills-based driver training has not reduced post-licence crashes or decreased the number of traffic offences (Elvik, 2010; Mayhew, 2007). For instance, improving the training of drivers in avoiding slippery road crashes through skid training in Finland did not result in a decrease of these events (Katila, Keskinen, Hatakka, & Laapotti, 2004). One possible reason for this is that the training made the drivers over-confident in their abilities.

Research has also considered the other effects of driver education apart from crashes. An evaluation of a one day program focussed on attitudes and risk perceptions as drivers, pre-drivers and passengers delivered within a school context within Australia suggested that those young people who completed the program reported riskier attitudes towards driving from the pre-program measurement to immediately after completing the program and then at the 6 week follow up period (Glendon, McNally, Jarvis, Chalmers, & Salisbury, 2014). Driver education may increase crash risk for novice drivers if it encourages them to obtain their licence at a younger age (Senserrick, 2007; Williams, 2006) or to progress through the licensing system at a faster rate. In New Zealand, young drivers who complete a driver education course progress through the graduated driver licensing system at a faster rate and obtain a full licence earlier. Research has shown that these drivers, who completed a driver education course and obtained their full licence sooner than those who did not complete a driver education course, have a higher involvement in crashes (Lewis-Evans, 2010) and have a higher risk of receiving a traffic offence within their first years of driving (Begg & Brookland, 2015).

However, there are some promising developments in the area of driver education. For instance, a large cohort study of young drivers in the Australian state of New South Wales identified that individuals who participated in a resilience-focused education program experienced reduced crash risk (Senserrick et al., 2009). This resilience-focused program included driver education issues as well as reduced risk taking more broadly. Approximately 500 students from a range of schools met at an off-site location for a 1 day seminar. This seminar is supported by range of additional activities including further workshops for students, fact sheets for parents and professional development sessions for teachers, health workers and community members. The specific additional activities undertaken depends on the school (Senserrick et al., 2009). Another education program which appears promising involves a three part program. The first part involves a mock crash while the second and final parts are facilitated classroom sessions. The entire program takes approximately 3 hours with the second and third parts delivered by trained teachers employed by the organisation delivering the driver education program and accompanied by the students' regular classroom teachers. An evaluation of the program indicated that participants had stronger intentions to speak up as a passenger to attempt to prevent a driver speeding. It was not possible to evaluate the effect of the program on crashes and offences due to resourcing constraints (Lewis, Fleiter, & Smith, 2015).

Driving simulators

Driving simulators have strong potential for enhancing driver education programs due to the flexibility and control they offer. This is beneficial because it allows the trainer to specify the environment exposing the learner to a wide variety of situations in a shorter period of time than would be needed to experience the same situations on-road (Kappe, van Emmerik, van Winsum, & Rozendom, 2003).They are also able to expose novice drivers to situations that are high risk and train them to more effectively manage these situations (Fisher, Glaser, Laurie, Pollatsek, & Brock, 1998; Fisher et al., 2002; Regan, Deery, & Triggs, 1998). There is evidence to suggest that using driving simulators to educate novice drivers can reduce crash rates (Allen, Park, Cook, & Fiorentino, 2007).

Education incorporating a driving simulator improves a range of driving skills (Bates, Filtness & Watson, 2018). The use of simulator education and training does appear to improve hazard perception skills (e.g. Carpentier, Wang, Jongen, Hermans, & Brijs, 2012; Chapman, Underwood, & Roberts, 2002; Fisher, Young, Zhang, Knodler, & Samuel, 2017; Pradhan, Fisher, & Pollatsek, 2006; Regan, Triggs, & Godley, 2000a, 2000b; Thomas et al., 2011). This education and training appears effective after four days (Pradhan et al., 2006) and four weeks (Carpentier et al., 2012; Regan et al., 2000b). A longer term follow up does not appear to have been conducted. Likewise, individuals who completed visual scanning education and training within a simulator took shorter glances away from the road when compared with drivers who did not receive this intervention (Thomas et al., 2011). Additionally, attentional control and decision making skills can also be trained with the use of simulation (Gopher, 1996; Regan et al., 1998).

Another benefit of driving simulators is they are able to provide an indication of whether a young person is likely to pass a driving test (de Winter et al., 2009). They are also able to assist in the prediction of offending behaviour after a driving test is passed (de Winter, 2013). In other cases, simulator education and training appears to be ineffective. Although there is limited research conducted to explore the role of simulators in the education of people who are not young drivers, one study identified that educating and training older drivers with a simulator failed to improve their visual attention (Haeger, Bock, Memmert, & Huttermann, 2018) indicating that we need to develop a greater understanding of when driver education is enhanced by a driving simulator.

Thus, a body of research suggests that there may be benefits of augmenting driving education with a simulator for some groups of drivers. However, the current evidence is not sufficient to give clear guidance on the safety benefits of the use of simulators as an educational tool across all driver groups. This most likely depends on whether the skills that these groups lack are able to be improved through the use of driving simulators. Thus this paper identifies disadvantaged groups known, or assumed to be, at an increased risk of crashing and analyses the extent to which simulators might be useful in assisting these groups. This paper addresses two research questions: (a) What role, if any, can simulation play as an education and/or training intervention for individuals disadvantaged because of individually-orientated concerns such as intellectual impairment or ADHD? (b) What role, if any, can simulation play as an education and/or training intervention for those who are disadvantaged because of their indigenous ethnicity?

Method

Review Methodology

A scoping review is a form of systematic literature review used to assess evidence in emerging fields of study and thus inform practice, policy, education and research (Peterson, Pearce, Ferguson, & Langford, 2017). This scoping review process was informed by the methods of Arksey and O'Malley (2005) and Levac, Colquhoun, and O'Brien (2010). This approach conformed to the structure of defining the research question, identifying relevant studies, study selection and charting the data. This methodology has been used previously (e.g. A. Bates, Matthews, Simpson, & Bates, 2016; L. Bates, Rodwell, & Matthews, 2019; Jones, Simpson, Briggs, & Dorsett, 2016).

Identifying the research question

It was first necessary to define the terms disadvantage, driving simulator and driver education. It is plausible to consider all novice and/or young drivers as disadvantaged due to lack of experience and increased crash risk. The research team decided that the target population of interest would include only those who were deemed within a study as being disadvantaged in a way other than exclusively by their youth or novice status. It also became apparent that while disadvantage is often a barrier to driver safety, appropriate driver education can also be viewed in terms of cultural suitability. Studies that addressed driver education specifically for the needs of indigenous peoples were therefore considered separately from studies with populations disadvantaged due to illness, disability or socio-economic reasons. This review does not impose a definition of driving simulator; instead all studies in which the original authors described their intervention as including a driving simulator where considered. However, studies were considered out of scope if the driving simulator was used as a measurement tool rather than for education. Driver education was any form of delivery, including a brief intervention or multiple sessions that were designed to help someone learn to drive.

The review was conducted to answer the following two questions: What role, if any, can simulation play as an education and/or training intervention for individuals disadvantaged because of individually-orientated concerns such as intellectual impairment or ADHD? What role, if any, can simulation play as an education and/or training intervention for those who are disadvantaged because of their indigenous ethnicity?

Identifying relevant studies

Searching was carried out using the online databases Informit, ScienceDirect, Web of Science, Psych Info, TRID, OVID, ERIC, Scopus and Australasian College of Road Safety (an expected source of information on indigenous Australians) in March 2017. As can be seen in Table 1 search terms relating to driver education or driving simulators were combined with population descriptors. Date restrictions were from January 1945 to March 2017. Only papers written in English were included. Conference abstracts were excluded as they did not provide sufficient information about the interventions.

Table 1: Search terms

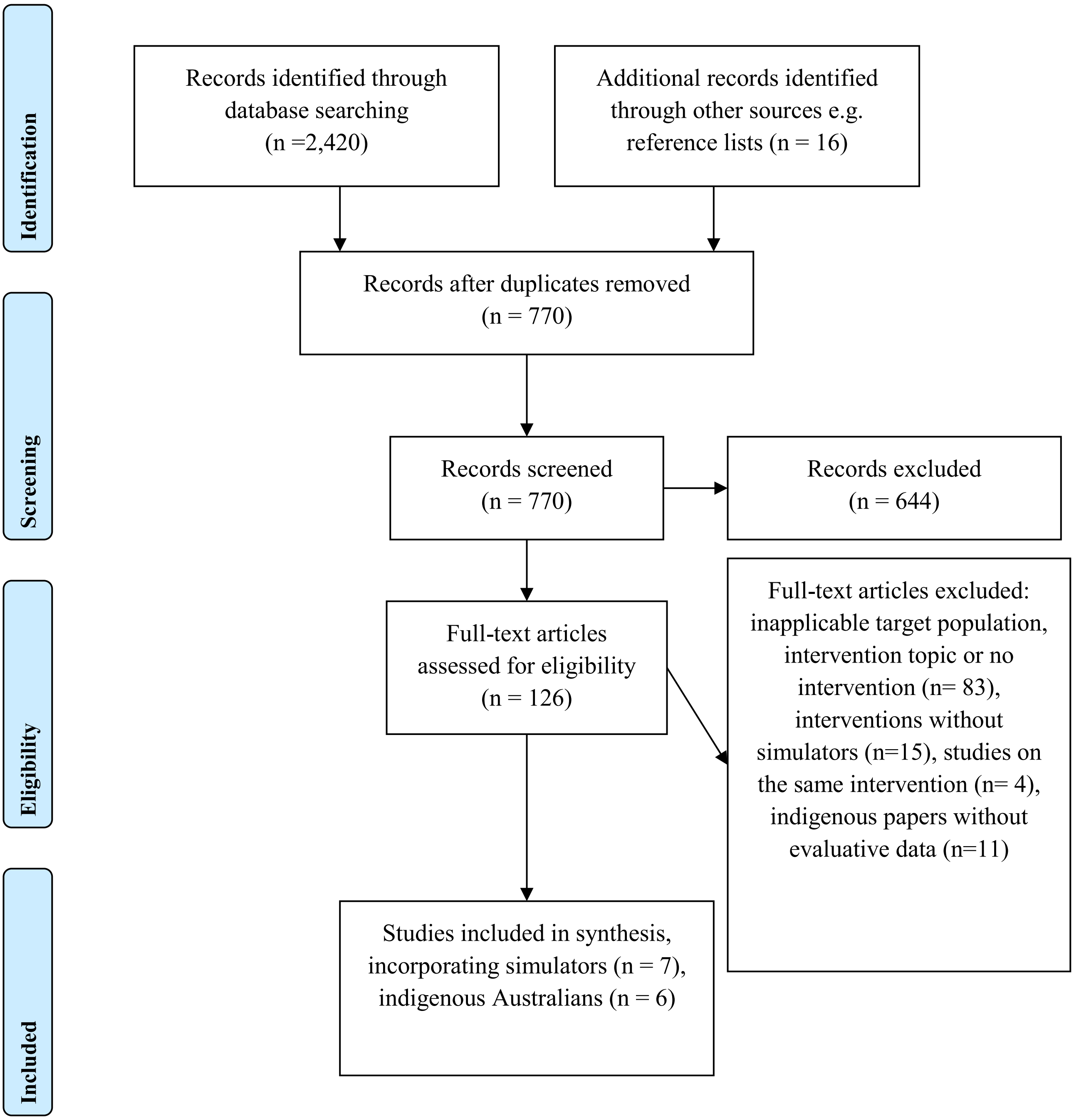
Driver education	"driv* train*" OR "driv* educat*" OR "adapt* educat*" OR "adapt* intervention*" OR "driv* intervention*" OR "tutor*" OR "instruct*" OR "teach*" OR "educat*" OR "train*" OR "supervis*" OR "practic*" OR "facilitate*" OR "mentor*" OR "coach*" OR "graduated driver licensing" OR "GDL" OR "GLS"
Driving simulators	driv* simulat*" OR "driv* simulat* program*" OR "similar*" OR "video*"
AND	
Student population	"learn* driv*" OR "novice driv*" OR "pre-learner driv*" OR "newly licensed" OR "inexperience* driv*" OR "provisional driv*" OR "teen* driv*" OR "intermediate driv*" OR "probationary driv*" OR "probationary licens*" OR "learn* licens*" OR "provisional licens*"
AND	
Disadvantaged population	"indigenous" OR "disadvantaged" OR "Aboriginal" OR "Native American" OR "American Indian" OR "native" OR "minority" OR "cultural adaptation" OR "Torres Strait Islander" OR "Maori" OR "Inuit" OR "youth" OR "young people"

Study selection

The study selection process is summarised in Figure 1. Title and abstract screening was conducted by one member of the research team. This screening resulted in 644 papers being removed from the review as they were not relevant to the question. The full-text papers were considered initially by one member of the research team. For papers where she was not certain of eligibility of inclusion, all members of the research team read the full texts. This was for 26 studies. Additional papers were identified from screening the reference lists and papers citing the shortlisted studies. This provided an additional nine full texts.

Studies were included if the primary focus was on driver education for a targeted population that was identified as being disadvantaged. The intervention must have also included a driving simulator component, but did not have to form the entirety of the intervention. Our initial search indicated that there were no interventions for an indigenous population that included a simulator. However, given our interest in this population, our awareness of the difficulties indigenous individuals face when obtaining a learner licence and the subsequent effects on education and employment, we decided to examine other licensing interventions targeted at indigenous peoples. Papers regarding interventions specifically for indigenous peoples were required to include a learning to drive intervention that was developed, delivered or adapted to consider the needs of indigenous students. This intervention did not need to include a simulator.

Figure 1: Literature review flow chart



Charting the data

Information on each of the final 13 studies was extracted and tabulated. Features of interest in the studies that were used to answer the research question were: target population and barriers to their driver education identified by the study, intervention features, simulator specifications, outcomes measured and key findings.

Results

Interventions incorporating simulators

Of the seven studies identified, all but one were conducted in the United States of America. The types of disadvantaged populations was limited to intellectual disabilities, attention deficit hyperactivity disorder and autism spectrum disorders. There were no studies that had an intervention with a simulator component conducted with an indigenous population. In only three studies was a comparison group used. The sample size ranged from six to 172 participants with three of the studies having less than eight participants. While all studies used a simulator within their intervention, one study also provided participants with practical education and training on a course, another provided sessions for both the young driver and their parents with a clinician and one included professional driving lessons.

Table 2 provides a summary of each study that was included within the review of interventions that had a simulator component. In all cases where information regarding the driving simulator was provided, they included the use of visual display screens. Many, but not all, included steering wheels as part of the hardware. The earliest study occurred in the 1970s (Zider, 1979). In this study the available simulator video was used without sound and had a physical instructor present to deliver appropriate instruction. This study identified that individuals were able to transfer what they had learnt in the simulator education and training to driving in a vehicle on a closed track. All subsequent studies were published from 2010 onwards. This suggests a recent increase in research interest regarding the use of driving simulators for driver education.

Two papers considered participants diagnosed with Autism Spectrum Disorder (ASD). The reasons for using a driving simulator for one study were that the simulator allowed drivers to safely focus on one skill at a time without the need to engage in other driving tasks simultaneously and driving task complexity could be introduced incrementally. Skills practised were upper body and lower body motor skills (Brooks et al., 2016). The driving simulator in the Wade et al. (2016) study was used because it could be adapted to the specific learning needs of people with ASD by providing personalised feedback. For both studies, participants improved in simulator driving tasks after education. However, on road driving ability was not assessed. Brooks et al. (2016) found that controls and ASD participants improved equally with education. There was no control or comparison groups included in the (Wade et al., 2016) study.

Drivers with Attention Deficit Hyperactive disorder (ADHD) were considered in three studies. Simulators were used in very different ways for these studies. Fabiano et al. (2011) used sessions in the driving simulator to give the novice drivers objective feedback on their strengths and limitations. Naturalistic driving data was collected using in-car sensors pre and post-intervention and suggested a trend of reduced speeding and hard braking. Poulsen, Horswill, Wetton, Hill, and Mui Lim (2010) used the simulator as a standalone intervention and identified the benefit of being able to be delivered in a distraction-free environment that allowed for frequent rest breaks and a one-on-one relationship between student and trainer. The focus was hazard perception and participants performed significantly better on a hazard perception test than controls post intervention.

The most comprehensive study to date that has used a driving simulator as part of an intervention for disadvantaged groups was by Fabiano et al. (2016). This was an experimental study with participants diagnosed with ADHD randomly assigned to one of two different treatment groups (there was no control group). The first group completed the Supporting the Effective Entry to the Roadway (STEER) program. This program involves parents undertaking a behavioural parenting program as well as communication education and training with their adolescent. There are also driving focused interventions including parental monitoring of driving behaviours and contracts designed to encourage safe driving. The second treatment group completed the Driver Education and Driver Practice (DEDP) condition. This group completed driver education classes and supervised on-road driving practice. Both treatment groups also involved a simulator component. Participants were then followed up six and twelve months after the treatment was completed. The study examined the effect of the two treatments on parenting interactions and driving behaviour. The results indicated that the more comprehensive program, the STEER program, was effective in reducing observed negative parenting behaviour and adolescent self-reported risky driving compared to the less comprehensive intervention.

All of the studies exposed participants to the simulator in small numbers or individual sessions with the exception of the most recent study by Fabiano et al. (2016). This approach allows each participant individual time with the simulator. There is no consistency in duration of simulator programs between the studies ranging from one session of 34 minutes (Poulsen, Horswill, Wetton, Hill, & Mui Lim, 2010) to 27 sessions of 60 minutes (Brooks et al., 2014). There is also inconsistency between presenting the simulator education as a standalone intervention (Brooks et al., 2016; Poulsen, Horswill, Wetton, Hill, & Mui Lim, 2010; Wade et al., 2016; Zider, 1979) or as one component of a larger intervention incorporating other teaching methods. These other methods included motivational interviewing (Fabiano et al., 2011), facilitated driver education textbook study (Brooks et al., 2014) and a more comprehensive program that incorporated driving with a professional driving instructor on the road (Fabiano et al., 2016).

Not all studies had outcome measures and those that did varied on whether they were task-focussed or independent. For example, some studies considered education and training as successful by counting the simulator tasks which could be completed without error (Brooks et al., 2016; Brooks et al., 2014; Zider, 1979). This approach clearly demonstrates the ability to learn a specific task but it does not consider if that task is beneficial for learning to drive. Other studies measured skills which would be expected of safe driving, such as travel at or below the speed limit, hazard perception or a reduction in harsh braking episodes (Fabiano et al., 2011; Poulsen, Horswill, Wetton, Hill, & Mui Lim, 2010; Wade et al., 2016). These may be considered as safety performance indicators, for which there is independent research evidence linking such adverse behaviours to crash risk. As such it may be considered that simulator education and training interventions which enhance behaviour of these key safety areas would likely reduce novice driver crash risk. However, in order to conclude similar from studies where task error is an outcome measure it is first necessary to evaluate the education and training itself to identify which safety-related behaviours are being targeted.

While all studies cited previous research to justify their approach, only one study cited using theoretical frameworks to guide intervention design. Zider (1979) adapted two theoretical frameworks, for selecting the task to be taught and how to break the task into smaller steps to make it appropriate for people with intellectual disabilities.

Interventions targeting indigenous Australians

Although the search terms included other native peoples (such as ‘native American’, ‘American Indian’, ‘Maori’, ‘Inuit’, ‘minority’, ‘cultural adaptation’, ‘minority’ and ‘disadvantaged’), only papers related to indigenous Australians were found. An earlier review has considered reasons why it is difficult for indigenous Australians to obtain a driver licence (Cullen, Clapham, Hunter, Treacy,

& Ivers, 2016). However, it did not consider interventions targeted at this group to assist them to gain a licence. The current review found six papers that discussed interventions aimed at assisting indigenous Australians to obtain a driver licence. The types of interventions varied but included learner driver mentor programs, train-the-trainer, small group activity interventions, case management and driving lessons. Most papers mentioned community ownership and responsibility for driver education as integral in making an intervention successful.

Table 3 provides further information regarding each of the papers included in the review. Two papers discussed learner driver mentoring programs (LDMP) that were made available to indigenous learner drivers and other community members (Freethy, 2012; McRae & Deans, 2014). The intervention typically paired learners with volunteers to provide legally required logbook hours of supervised practice. One study identified that a focus on licence test pass rates was an insufficient measure for success. The authors highlighted that a focus on teaching driving skills did not mean that young people were being taught to drive safely (McRae & Deans, 2014). The second study found an improvement in safe driving attitudes and behaviour within communities. The disparity may be found in the specific programs reviewed by Freethy (2012), which were tailored to suit each community. This was done by working to prepare young people for the inevitable challenges of learning to drive in one community and engaging a highly respected local elder to manage the mentor program in another (Freethy, 2012).

Two papers described programs developed with close consultation and sensitivity to specific indigenous communities (McIlwraith, 2001; Somssich, 2009). These papers both developed an intervention that could be applied to other indigenous communities by being flexible enough to respond to each community's individual needs. McIlwraith (2001) described developing an intervention that was then implemented with other indigenous communities by producing a resource pack for distribution. Community agencies were then given packs to implement programs independently. The paper cited communities using resources in unintended ways such as in family groups with more diverse ages. The most recent paper (Cullen, Clapham, Byrne, et al., 2016) was a process evaluation of a case management approach. In this intervention, an Aboriginal youth worker assists individuals to access local services and mentoring as well as helping manage any licensing fines or sanctions by liaising with organisations such as transport and debt recovery offices.

All papers, bar one, lack substantial empirical evaluation of each program beyond pass rate statistics and informal qualitative data. Instead, the process of intervention development and delivery was the main topic for all papers. McIlwraith (2001) stated an intention to perform an evaluation of licence pass rates of participants in the future. Long term follow up information on road safety improvements was also unreported. However, Somssich (2009) noted factors such as inaccurate records, low literacy skills and unreachable former participants common in indigenous communities that may make research difficult.

Two of the papers were process evaluations. Cullen, Clapham, Byrne, et al. (2016) undertook a comprehensive process evaluation that included 194 individuals. They were able to identify that the intervention was being delivered as planned. No studies contained experimental designs to test program effectiveness or best practice. There was no information regarding sample sizes or comparison groups. The Cullen, Chevalier, Hunter, Gadsden, and Ivers (2017) study was a mixed methods design incorporating 30 interviews with program staff, clients and stakeholders as well as a quantitative analysis of licensing data.

Table 2: Interventions with a simulator component

1st Author, year, country	Study design features	Population targeted	Key features of intervention	Simulator features	Outcomes measured	Key findings/results
Zider (1979) America	Quasi-experimental	Non-drivers with an IQ score between 40 and 55.	Participants (n=6) attended driving simulator sessions in pairs and took turns watching the other's education.	Link, Singer driving simulator, with car seat, gears, pedals, speedometer, steering wheel.	Trials, errors and time till success criteria met. Qualitative data.	All participants were able to demonstrate fewer errors after undergoing education and the simulator participants were able to transfer skills learnt in the simulator to the closed track.
Poulsen, Horswill, Wetton, Hill, and Mui Lim (2010) Australia	Quasi-experimental	Males with scores 1.5 SD above the normed mean on the ADHD Current Symptoms Scale for Adults.	After watching an instructional video on how to anticipate hazards, participants provided a spoken commentary of what they were paying attention to during footage of a road.	Driver point of view footage of true to life traffic interactions presented on a PC.	Reaction time in hazard perception test.	Participants who received the hazard perception training had significantly faster reaction times than a control group.
Fabiano et al. (2011) America	Feasibility study	Met DSM diagnosis criteria of ADHD via structured interview, IQ above 80, aged 16 or 17 years.	8 week parent and participant (n = 7) program featuring two 45 minute sessions per week. Parents and participants had a session alone with a clinician and then a joint session. A driving simulator was used to practise driving skills and raise awareness for	Not provided	Top speed, time spent driving above 70 mph, sudden/hard braking and acceleration, Impairment Rating Scale (IRS), Driver Behaviour Questionnaire (DBQ), parent and participant	A trend of improvement was observed in all driving measures except sudden/hard acceleration with effect sizes ranging from 0-.30. Scores improved on the DBQ (effect size = .51).

			the driver of their behavioural weaknesses.		satisfaction with intervention.	
1st Author, year, country	**Study design features**	**Population targeted**	**Key features of intervention**	**Simulator features**	**Outcomes measured**	**Key findings/results**
Brooks et al. (2014) America	Pilot of program	Those meeting DSM criteria for an intellectual disability.	Three practice scenarios with visual and auditory feedback to alert to lane departures and cued stopping locations and three testing tracks that were advanced through upon successful completion of prior tracks.	Small-footprint DriveSafety CDS-250 driving simulator with adjustable driver's seat and standard automatic vehicle controls, dash board and three screens providing 110^{o} compressed field of view	Time spent per activity and track, no. of trials, lane marking and off-road contact, average speed.	Of the four participants, only one was able to complete all scenarios at all levels before study completion.
(Brooks et al., 2016) America	Experimental	Young adults aged 13-21 with diagnosed ASD and control	Education tasks were to turn the wheel and press the pedals to follow a static then moving target on screen.	DriveSafety CDS-250, fixed base with feedback, partial cab of a car with three monitors side by side, automatic vehicle controls.	Number of trials required to error free completion, total time to complete all levels, error size (in degrees), time to first error, total errors.	ASD and controls had non-significant differences on all measures except ASD participants requiring on average 30-35 minutes more time to complete the education.
Wade et al. (2016) America	Experimental	Adolescents aged 13-18 years diagnosed with autism spectrum disorder.	A desk-top driving simulator with advancing levels of activities to complete. Drivers using the desk-top simulator had their gaze monitored. Essential	Virtual Reality Adaptive Driving Intervention Architecture (VIDA) that monitors gaze patterns and incorporates	Trial duration and trial failures on a testing simulator task.	Both groups completed the testing tasks faster and with less errors after education (n=20). Comparisons between the two groups were not made.

			items in the visual field requiring attention were highlighted on the screen. They attended six sessions.	observer assessment. Displayed on a standard PC screen with steering wheel and three peddle controls (Logitech G27).		
1st Author, year, country	**Study design features**	**Population targeted**	**Key features of intervention**	**Simulator features**	**Outcomes measured**	**Key findings/results**
Fabiano et al. (2016) America	Experimental	Adolescents aged 16-18 years diagnosed with Attention Deficit Hyperactivity Disorder	Twelve week intervention. Both groups engaged in weekly classroom instruction, practical driving lessons and three simulation exercises. One group also engaged in an eight week parent-teen intervention with a psychologist.	The simulator included a real car cabin with a steering wheel and pedals.	Parenting behaviours. Risky driving behaviours.	Those who received the additional eight weeks of parent-teen intervention had reduced negative parenting behaviours. This was maintained at the six month follow up and was waning at the 12 month follow up. The parent-teen intervention group self-reported fewer risky driving behaviours although this was not found in the naturalistic data.

Table 3: Interventions for an indigenous population

1st Author, year, country	Study design features	Population targeted	Key features of intervention	Outcomes measured	Key findings/results
McIlwraith (2001) Australia	Narrative account	Developed initially with an Aboriginal community then generalised to other communities.	Avoided computer-based activities in favour of group activities.	Uptake by communities and agencies. Participant licence test pass rates. Returning participants.	No formal statistical analyses were performed. Anecdotal reports were positive and suggested the resources aided users to get a driver licence.
McRae and Deans (2014) Australia	Qualitative interviews and quantitative survey	Young people from: lower socio-economic, rural, remote or Aboriginal communities as well as those who have unlicensed parents, are from single parent families or have other siblings of learner permit age.	Community-based programs that match novice drivers with an experienced volunteer driver who supervises a portion of their driving hours.	N/A	Thirty-two Learner Driver Mentor Programs were found to be in operation Australia wide. Eligibility criteria for participation varied between programs, the majority expressly include Aboriginal and Torres Strait Island communities.
1st Author, year, country	**Study design features**	**Population targeted**	**Key features of intervention**	**Outcomes measured**	**Key findings/results**
Somssich (2009) Australia	Overview of impacts of legislative change and interventions.	Indigenous Northern Territory (NT) residents.	An intervention that was previously delivered over a single three week period was required to be delivered over two periods six months apart to comply with legislative change of	None	Changes to driver licensing that may be effective for mainstream drivers are frequently inappropriate for indigenous NT populations.

			mandatory six months learner permit status.		
Freethy (2012) Australia	Qualitative program review	Those who can demonstrate disadvantage in obtaining a driver licence.	A network of Government funded programs that provide a volunteer mentor, who is an experienced driver, to a learner driver to aid in supervision of the mandatory 120 logbook hours of supervised driving.	Licence test pass rates and total supervised hours.	Fifty-five Victorian Government funded mentor programs were examined. Approx. 12,000 hours of supervision and 84 licences were achieved in one quarter of 2012.
Cullen, Clapham, Byrne, et al. (2016) Australia	Process evaluation	Aboriginal Australians living in three areas: Redfern, Griffith and Shellharbour.	Providing individualised support to Aboriginal Australians through the case management support of an Aboriginal youth worker.	Participant characteristics and whether services were being delivered.	The pilot program is working well and is being delivered as planned.
Cullen et al. (2017) Australia	Process evaluation	Aboriginal Australians facing licensing issues living in remote areas of the Northern Territory.	Facilitate and assist individuals to obtain a provisional licence through a structured program.	Increase in number of licences held in remote communities.	Program is achieving licensing outcomes in remote areas.

Discussion

As noted by Mayhew (2007) and Mayhew and Simpson (2002), there are several requirements for driver education and training to be successful in achieving crash reductions. Firstly, it needs to address the factors that cause crashes, trainees need to have the motivation to use what they have learnt and the training and education needs to be appropriate for the group that is receiving it. Simulators are actually mainly used as an evaluation tool (e.g. Filtness, Reyner, & Horne, 2012; Watling, Smith, & Horswill, 2014), rather than a tool to develop an enriched and targeted education program for disadvantaged groups.

The use of a driving simulator within driver education for disadvantaged groups is in its infancy, as apparent from the limited number of publications found during this scoping review. The reported studies tended to conclude that there were benefits resulting from the use of their intervention. This is promising and suggests that there are advantages in continuing to explore the use of simulators to improve driver education for these groups. One encouraging finding from Zider (1979) is that participants who undertook the simulator education were able to transfer what they had learnt to their driving in a vehicle while on a closed track. This is important because it demonstrates that participants were able to retain what they had learnt while in a simulator and then transfer it to a different context.

Additionally, research has shown hazard perception training to be effective in improving the hazard perception skills of drivers (e.g. Castro et al., 2016; Horswill, 2016; Horswill, Garth, Hill, & Watson, 2017; Vlakveld, 2014; Wetton, Hill, & Horswill, 2013). Therefore the fact that the Poulsen, Horswill, Wetton, Hill, and Lim (2010) study indicates that this training is also effective for minority groups such as those with ADHD is an important finding. This indicates the importance of taking training and education concepts that have been demonstrated as effective and evaluate them with different groups. These benefits were identified despite some non-significant findings, small sample sizes, lack of a control group and experiencing difficulty with participants completing the intervention in full across the studies included. Additionally, the types of disadvantaged groups considered are very limited in scope, with a focus on intellectual disabilities, attention deficit disorders and autism. Populations with social or economic disadvantages, such as remote or indigenous populations, and the use of simulators to help educate drivers in these groups and thus reduce the effect of these disadvantages, has been completely disregarded by the research community so far.

It is important to note that simulators are a tool that is used to deliver driver education programs rather than being a driver education program itself. Simulators are presented in the reviewed papers as being flexible, as they provide control over the cognitive load of novice drivers, and hence allow learners to acquire driving skills at their own pace. They were also used at different points in the learning process. In some cases they were used for individuals that had no driving experience and in other situations for individuals who had some on-road experience. While there is no research evidence from the studies above suggesting that there is an optimal time in the learning process to use a simulator for education, the work by Regan et al. (1998) suggests that it is more beneficial to provide this within the intermediate licensing phase.

Most of the reviewed studies used the simulator to teach vehicle control skills rather than higher level skills such as hazard perception. The studies did not provide any guidance toward which skills should be targeted with simulators, the necessary duration of education in the simulator, whether a simulator could be used as a standalone tool, or otherwise, how to effectively incorporate it within a program.

The studies also had limited scientific validity: they used low sample sizes, and more importantly they lacked the presence of a control group. Overall, they did not evaluate whether the skills learnt in the simulator transferred to the real road (except for one study on a test track), and whether the helped participants to become safe drivers. No study mentioned whether the education and training led to the participants obtaining a driver licence and then driving on-road. Given that incorporating simulators into driver education programs for young drivers shows promise (Hirsch & Bellavance, 2017), there is a need to consider their effect on disadvantaged populations.

No education program for indigenous populations using a driving simulator could be found in the literature. The limited literature found in our review is consistent with the review by Cullen, Clapham, Hunter, et al. (2016) which included 12 papers regarding barriers for indigenous people wishing to obtain a driver licence. In the current review, the included studies lacked scientific rigour and focussed on describing interventions targeting this group. Different interventions for indigenous populations were focussed on increasing the chance of obtaining a driver licence as opposed to improving road safety. Such an approach is the result of the difficulties inherent to the development of interventions for this disadvantaged group, with the need to overcome literacy issues, adapt programs to the local culture, and provide the intervention with the assistance of local partners. This is often challenging, but crucial to the long term success of interventions.

While a greater proportion of indigenous people live in rural and remote locations, research suggests that this geographic context is important for people regardless of ethnicity (Edmonston, Sheehan & Siskind, 2009). Thus there is a need to investigate how interventions that incorporate a driving simulator can be used in areas of sparse population. The use of PC based interventions is one option as this removes the requirement to take a more traditional simulator to each location. It also enables education to occur for larger groups of individuals. Research with a sample of high school students aged 16 and 17 years within the United States of America indicates that it is possible to use PCs to develop risk awareness skills (Fisher et al., 2002).

However, it is not possible to transfer an education program from one platform to another. When deciding what type of simulator is appropriate for a driver education and training program, two important considerations are fidelity, or similarity to real-life, and validity. There are two types of fidelity: physical fidelity and psychological fidelity. Validity refers to how effectively behaviours learnt in a driving simulator transfer to real life (Bates, Filtness & Watson, 2018). It is possible to have a low-fidelity simulator which has high validity. These are important considerations because research suggests that simulators with different levels of fidelity have different effects on novice driver crash rates (Allen et al., 2007).

Very few evaluations of driver education initiatives are undertaken despite them being needed to ensure the implementation of evidence based policy (Glendon, 2014). Our review indicates that there is a clear need for a significant amount of further research regarding the inclusion of simulators into driver education programs for disadvantaged populations. Additionally, there is a need for research that identifies how much education in a simulator is optimal and whether this should be self-paced. The outcome measures included in the reviewed studies make it difficult to identify the safety and crash reduction benefits of these types of programs. Future research needs to collect evidence regarding this, either by a longitudinal examination of crash and offence records or by measuring a behaviour which is known to be associated with crash risk such as travelling above the posted speed limit.

A limitation of this study is that, while there were a number of search terms used to identify groups that may have been 'disadvantaged' as the result of their ethnic minority status, there were no search terms used to identify other forms of disadvantage such as intellectual disability, ADHD or geographical remoteness. Therefore, the results and conclusions are restricted and do not address these factors. Caution should be used when interpreting findings and conclusions. Future research could address this limitation by including more specific search terms to address these factors.

Conclusions

This review has investigated the research evidence for interventions that could be used to improve the safety of disadvantaged young people on the roads by reducing crashes and injuries. There are limited studies within this area highlighting the lack of research evidence for an initiative of this type making it difficult to develop evidence based policy and practice. However, based on the studies reviewed it does appear that (a) simulator education and training can be retained and transferred to practical contexts (b) Hazard Perception Training, which appears to have some benefits for mainstream drivers, may also have some benefits for those with ADHD and (c) indigenous programs are more focussed on obtaining a drivers licence rather than improving road safety. There is a need to conduct further research regarding the incorporation of a driving simulator into education and training for disadvantaged groups with a particular need for theoretically grounded research regarding those who are disadvantaged for social or geographic reasons such as young people living in remote areas or indigenous persons.

Funding

This research was supported by the Australian Government through the Australian Research Council's *Linkage Projects* funding scheme (LP140100409).

References

Allen, R. W., Park, G. D., Cook, M., & Fiorentino, D. (2007). *The effect of driving simulator fidelity on training effectiveness.* Paper presented at the Proceedings of the Driving Simulator Conference North America, Iowa City, Iowa.

Arksey, H., & O'Malley, L. (2005). Scoping studies: towards a methodological framework. *International Journal of Social Research Methodology, 8*(1), 19-32. doi:10.1080/1364557032000119616

Bates, A., Matthews, S., Simpson, G., & Bates, L. (2016). Brain injury as the result of violence: A systematic scoping review. *Journal of Social Work in Disability and Rehabilitation, 15*(3-4), 305-331. doi:dx.doi.org/10.1080/1536710X.2016.1220886

Bates, L., Filtness, A., & Watson, B. (2018). Driver education and licensing programs. In D. Lord & S. Washington (Eds.), *Safe Mobility: Challenges, Methodology and Solutions* (Vol. 11): Emerald Publishing Limited.

Bates, L., Rodwell, D., & Matthews, S. (2019). Young driver enforcement within graduated driver licensing systems: A scoping review. *Crime Prevention and Community Safety, 21*(2), 116-135. doi:10.1057/s41300-019-00061-x

Bates, L., Watson, B., & King, M. (2006). *Competing or Complementing: Driver Education and Graduated Driver Licensing.* Paper presented at the Road Safety Research, Policing and Education Conference, Gold Coast.

Beanland, V., Goode, N., Salmon, P., & Lenne, M. (2013). Is there a case for driver training? A review of the efficacy of pre- and post-licence driver training. *Safety Science, 51*, 127-137.

Begg, D. J., & Brookland, R. (2015). Participation in driver education/training courses during graduated driver licensing, and the effect of a time-discount on subsequent traffic offenses: Findings from the New Zealand Drivers Study. *Journal of Safety Research, 55*, 13-20. doi:10.1016/j.jsr.2015.07.003

Brooks, J., Kellett, J., Seeanner, J., Jenkins, C., Buchanan, C., Kinsman, A., . . . Pierce, S. (2016). Training the motor aspects of pre-driving skills of young adults with and without Autism Spectrum Disorder. *Journal of Autism and Developmental Disorders, 46*(7), 2408-2426. doi:doi.org/10.1007/s10803-016-2775-8

Brooks, J., Mossey, M., Tyler, P., & Collins, J. (2014). An exploratory investigation: are driving simulators appropriate to teach pre-driving skills to young adults with intellectual disabilities? *British Journal of Learning Disabilities, 42*(3), 204-213. doi:doi.org/10.1111/bld.12029

Carpentier, A., Wang, W., Jongen, E. M. M., Hermans, E., & Brijs, T. (2012). *Training hazard perception of young novice drivers - a driving simulator study*. Paper presented at the TRB 2013 Annual Meeting.

Castro, C., Ventsislavova, P., Pena-Suarez, E., Gugliotta, A., Garcia-Fernandez, P., Eisman, E., & Crundall, D. (2016). Proactive listening to a training commentary improves hazard prediction. *Safety Science, 82*, 144-154. doi:doi.org/10.1016/j.ssci.2015.09.018

Cercarelli, L. (1994). Road crashes involving aboriginal people in Western Australia. *Accident Analysis & Prevention, 26*(3), 361-369. doi:doi.org/10.1016/0001-4575(94)90009-4

Cercarelli, L., & Knuiman, M. (2002). Trends in road injury hospitalisation rates for Aboriginal and non-Aboriginal people in Western Australia, 1971-97. *Injury Prevention, 8*, 211-215. doi:dx.doi.org/10.1136/ip.8.3.211

Chapman, P., Underwood, G., & Roberts, K. (2002). Visual search patterns in trained and untrained novice drivers. *Transportation Research Part F: Traffic Psychology and Behaviour, 5*(2), 157-167.

Clapham, K., Senserrick, T. M., Ivers, R., & Lyford, M. (2008). Understanding the extent and impact of Indigenous road trauma. *Injury: International Journal of Care of the Injured, 39*(Supplement 5), s19-s23. doi:10.1016/S0020-1383(08)70025-1

Clapham, K., Senserrick, T. M., Ivers, R., Lyford, M., & Stevenson, M. (2008). Understanding the extent and impact of Indigenous road trauma. *Injury, 39*(Supplement 5), S19-S23. doi:doi.org/10.1016/S0020-1383(08)70025-1

Cullen, P., Chevalier, A., Hunter, K., Gadsden, T., & Ivers, R. (2017). 'The program was the solution to the problem': Process evaluation of a multi-site driver licensing program in remote communities. *Journal of Transport & Health, 4*, 81-89. doi:doi.org/10.1016/j.jth.2016.07.004

Cullen, P., Clapham, K., Byrne, J., Hunter, K., Rogers, K., Senserrick, T. M., . . . Ivers, R. (2016). Implementation of a driver licensing support program in three Aboriginal communities: a brief report from a pilot program. *Health Promotion Journal of Australia, 27*(2), 167-169. doi:dx.doi.org/10.1071/HE15089

Cullen, P., Clapham, K., Hunter, K., Treacy, R., & Ivers, R. (2016). Challenges to driver licensing participation for Aboriginal people in Australia: A systematic review of the literature. *International Journal for Equity in Health, 15*, 134-143. doi:10.1186/s12939-016-0422-9

Curry, A., Yerys, B., Metzger, K., Carey, M., & Power, T. (2019). Traffic crashes, violations, and suspensions among young drivers with ADHD. *Pediatrics*. doi:10.1542/peds.2018-2305

de Winter, J. C. F. (2013). Predicting self-reported violations among novice license drivers using pre-license simulator measures. *Accident Analysis & Prevention, 52*, 71-79.

de Winter, J. C. F., de Groot, S., Mulder, M., Wieringa, P. A., Dankelman, J., & Mulder, J. (2009). Relationships between driving simulator performance and driving test results. *Ergonomics, 52*(2), 137-153. doi:10.1080/00140130802277521

Desapriya, E., Fujiwara, T., Verma, P., Babul, S., & Pike, I. (2011). Comparison of on-reserve road versus off-reserve road motor vehicle crashes in Saskatchewan, Canada. *Asia Pacific Journal of Public Health, 23*(6), 1005-1020. doi:doi.org/10.1177/1010539510361787

Edmonston, C., Sheehan, M., & Siskind, V. (2009). *'It's just the way it is out here....': The role of 'remoteness' and 'context' in understanding and preventing rural road trauma*. Paper presented at the Australasian Road Safety Research, Policing and Education Conference, Sydney.

Elvik, R. (2010). Why some road safety problems are more difficult to solve than others. *Accident Analysis & Prevention, 42*, 1089-1096.

Fabiano, G. A., Hulme, K., Linke, S., Nelson-Tuttle, C., Pariseau, M., Gangloff, B., . . . Buck, M. (2011). The Supporting a Teen's Effective Entry to the Roadway (STEER) Program: Feasibility and Preliminary Support for a Psychosocial Intervention for Teenage Drivers With ADHD. *Cognitive and Behavioral Practice, 18*(2), 267-280. doi:10.1016/j.cbpra.2010.04.002

Fabiano, G. A., Schatz, N., Morris, K., Willoughby, M., Vujnovic, R., Hulme, K., . . . Pelham, W. (2016). Efficacy of a family-focused intervention for young drivers with attention-deficit hyperactivity disorder. *Journal of Consulting and Clinical Psychology, 84*(12), 1078-1093. doi:dx.doi.org/10.1037/ccp0000137

Filtness, A., Reyner, L., & Horne, J. (2012). Driver sleepiness—Comparisons between young and older men during a monotonous afternoon simulated driv. *Biological Psychology, 89*(3), 580-583. doi:dx.doi.org/10.1016/j.biopsycho.2012.01.002

Fisher, D. L., Glaser, R., Laurie, N., Pollatsek, A. P., & Brock, J. (1998). *Evaluation of PC-based younger driver training program: Use of a driving simulator.* Paper presented at the Human Factors and Ergonomics Society 42nd Annual Meeting, Chicago.

Fisher, D. L., Laurie, N., Glaser, R., Connerney, K., Pollatsek, A. P., Duffy, S., & Brock, J. (2002). Use of a fixed-base driving simulator to evaluate the effects of experience and PC-based risk awareness training on drivers' decisions. *Human Factors: The Journal of the Human Factors and Ergonomics Society, 44*(2), 287-302. doi:doi.org/10.1518/0018720024497853

Fisher, D. L., Young, J., Zhang, L., Knodler, M., & Samuel, S. (2017). *Accelerating teen driver learning: Anywhere anytime training*. Retrieved from Washington DC:

Freethy, C. J. (2012). *L2P learner driver mentor program: extending driver licensing reach in disadvantaged communities*.

Glendon, A. I. (2014). An approach to novice driver training. *European Review of Applied Psychology, 64*(3), 111-122. doi:dx.doi.org/10.1016/j.erap.2014.04.003

Glendon, A. I., McNally, B., Jarvis, A., Chalmers, S., & Salisbury, R. (2014). Evaluating a novice driver and pre-driver road safety intervention. *Accident Analysis & Prevention, 64*, 100–110.

Gopher, D. (1996). Attention control: explorations of the work of an executive controller. *Cognitive Brain Research, 5*(1-2), 23-38. doi:doi.org/10.1016/S0926-6410(96)00038-9

Haeger, M., Bock, O., Memmert, D., & Huttermann, S. (2018). Can driving-simulator training enhance visual attention, cognition and physical functioning in older adults?q. *Journal of Aging Research, 2018*, 1-9. doi:10.1155/2018/7547631

Hirsch, P., & Bellavance, F. (2017). *Transfer of training of driving skills learned on a driving simulator to on-road driving behavior.* Paper presented at the TRB Annual Meeting, Washington, US.

Horswill, M. (2016). Improving fitness to drive: The case for hazard perception training. *Australian Psychologist, 51*, 173-181. doi:10.1111/ap.12132

Horswill, M., Garth, M., Hill, A., & Watson, M. (2017). The effect of performance feedback on drivers' hazard perception ability and self-ratings. *Accident Analysis & Prevention, 101*, 135-142. doi:doi.org/10.1016/j.aap.2017.02.009

Jerome, L., Segal, A., & Habinski, L. (2006). What we know about ADHD and driving risk: A literature review, meta-analysis and critique. *Journal of the Canadian Academy of Child and Adolescent Psychiatry, 15*(3), 105-125.

Jones, K., Simpson, G., Briggs, L., & Dorsett, P. (2016). Does spirituality facilitate adjustment and resilience among individuals and families after SCI? *Journal of Disability and Rehabilitation, 38*(10), 921-935. doi:dx.doi.org/10.3109/09638288.2015.1066884

Juarez, P., Schlundt, D. G., Goldzweig, I., & Stinson, N., Jr. (2006). A conceptual framework for reducing risky teen driving behaviors among minority youth. *Injury Prevention, 12*(suppl_1), i49-55.

Kappe, B., van Emmerik, M., van Winsum, W., & Rozendom, A. (2003). *Virtual instruction in driving simulators*. Paper presented at the Driving Simulator Conference, Dearborn, Michigan, United States of America.

Katila, A., Keskinen, E., Hatakka, M., & Laapotti, S. (2004). Does increased confidence among novice drivers imply a decrease in safety? The effects of skid training on slippery road accidents. *Accident Analysis & Prevention, 36*(4), 543-550.

Langford, J. (2002). Using the research to reduce novice driver crashes. In *Proceedings of the Developing Safer Drivers and Riders Conference*. Brisbane: ACRS and Travelsafe Committee.

Levac, D., Colquhoun, H., & O'Brien, K. (2010). Scoping studies: advancing the methodology. *Implementation Science, 5*(69), 1-9. doi:10.1186/1748-5908-5-69

Lewis-Evans, B. (2010). Crash involvement during the different phases of the New Zealand Graduated Driver Licensing System (GDLS). *Journal of Safety Research, 41*, 359-365.

Lewis, I., Fleiter, J., & Smith, J. (2015). *Students' responses to the RACQ Docudrama program*. Paper presented at the Australasian Road Safety Conference, Gold Coast, Queensland.

Mayhew, D. (2007). Driver education and graduated licensing in North America: Past, present, and future. *Journal of Safety Research, 38*(2), 229-235.

Mayhew, D., & Simpson, H. (2002). The safety value of driver education and training. *Injury Prevention, 8*(supplement II), ii3-ii8.

McDowell, A., Begg, D. J., Connor, J., & Broughton, J. (2011). Road safety attitudes and opinions of newly licensed Māori car drivers: New Zealand Drivers Study. *Australian and New Zealand Journal of Public Health, 35*(1), 93. doi:doi.org/10.1111/j.1753-6405.2010.00672.x

McIlwraith, M. (2001). *Learner's licence training project resources*.

McRae, D., & Deans, A. (2014). *Learner Driver Mentor Programs (LDMPs): a long term review*.

Peterson, J., Pearce, P., Ferguson, L., & Langford, C. (2017). Understanding scoping reviews: Definition, purpose, and process. *Journal of the American Association of Nurse Practitioners, 29*, 12-16. doi:10.1002/2327-6924.12380

Poulsen, A., Horswill, M., Wetton, M., Hill, A., & Lim, S. (2010). A brief office-based hazard perception intervention for drivers with ADHD symptoms. *Australian and New Zealand Journal of Psychiatry, 44*, 528-534. doi:10.3109/00048671003596048

Poulsen, A., Horswill, M. S., Wetton, M. A., Hill, A., & Mui Lim, S. (2010). A brief office-based hazard perception intervention for drivers with ADHD symptoms. *The Royal Australian and New Zealand Collage of Psychiatrists, 44*(6), 528-534. doi:10.3109/00048671003596048

Pradhan, A., Fisher, D. L., & Pollatsek, A. P. (2006). Risk perception training for novice drivers: Evaluating duration of effects on training on a driving simulator. *Transportation Research Record, 1969*, 58-64.

Regan, M. A., Deery, H., & Triggs, T. J. (1998). *Training for attentional control in novice car drivers: A simulator study.* Paper presented at the Proceedings of the Human Factors and Ergonomics Society Annual Meeting, Chicago.

Regan, M. A., Triggs, T. J., & Godley, S. T. (2000a). *Evaluation of a novice driver CD-ROM based training program: A simulator study.* Paper presented at the Human Factors and Ergonomics Society Annual Meeting.

Regan, M. A., Triggs, T. J., & Godley, S. T. (2000b). *Simulator-based evaluation of the DriveSmart novice driver CD-ROM training product.* Paper presented at the Road Safety Research Policing and Education Conference.

Reimer, B., Mehler, B., D'Ambrosio, L., & Fried, R. (2010). The impact of distractions on young adult drivers with attention deficit hyperactivity disorder (ADHD). *Accident Analysis & Prevention, 42*(3), 842-851. doi:doi.org/10.1016/j.aap.2009.06.021

Rosenbloom, T., & Wultz, B. (2011). Thirty-day self-reported risky driving behaviors of ADHD and non-ADHD drivers. *Accident Analysis & Prevention, 43*(1), 128-133.

Sargent, M., Begg, D. J., Broughton, J., Stephenson, S., Wright, C., & Baxter, J. (2004). Motor vehicle traffic crashes involving Maori. *The New Zealand Medical Journal, 117*(1188), 1-9.

Senserrick, T. (2007). Recent developments in young driver education, training and licensing in Australia. *Journal of Safety Research, 38*(2), 237-244.
Senserrick, T., Ivers, R., Boufous, S., Chen, H.-Y., Norton, R., Stevenson, M., . . . Zask, A. (2009). Young driver education programs that build resilience have potential to reduce road crashes. *Pediatrics, 124*, 1287-1292.
Shope, J. T. (2006). Influences on youthful driving behavior and their potential for guiding interventions to reduce crashes. *Injury Prevention, 12*(suppl_1), i9-14.
Somssich, E. (2009). Driver training and licensing issues for indigenous people. *Journal of the Australasian College of Road Safety, 20*(1), 31-36.
Thomas, F. D., Pollatsek, S., Pradhan, A., Divekar, G., Blomberg, R. D., Reagan, I., & Fisher, D. L. (2011). *Field and simulator evaluations of a PC-based attention maintenance training program*. Retrieved from Washington DC:
Vaa, T. (2014). ADHD and relative risk of accidents in road traffic: A meta-analysis. *Accident Analysis & Prevention, 62*, 415-425. doi:doi.org/10.1016/j.aap.2013.10.003
Vlakveld, W. (2014). A comparative study of two desktop hazard perception tasks suitable for mass testing in which scores are not based on response latencies. *Transportation Research Part F: Traffic Psychology and Behaviour, 22*, 218-231. doi:doi.org/10.1016/j.trf.2013.12.013
Wade, J., Zhang, L., Bian, D., Fan, J., Swanson, A., Weitlauf, A., . . . Sarkar, N. (2016). A Gaze-Contingent Adaptive Virtual Reality Driving Environment for Intervention in Individuals with Autism Spectrum Disorders. *ACM Transactions on Interactive Intelligent Systems (TiiS), 6*(1), 689-697. doi:10.1145/2892636
Watling, C., Smith, S., & Horswill, M. (2014). Stop and revive? The effectiveness of nap and active rest breaks for reducing driver sleepiness. *Psychophysiology, 51*(11), 1131-1138. doi:10.1111/psyp.1225
Wetton, M., Hill, A., & Horswill, M. (2013). Are *what happens next* exercises and self-generated commentaries useful additions to hazard perception training for novice drivers? *Accident Analysis & Prevention, 54*, 57-66. doi:doi.org/10.1016/j.aap.2013.02.013
Williams, A. (2003). Teenage drivers: Patterns of risk. *Journal of Safety Research, 34*, 5-15.
Williams, A. (2006). Young driver risk factors: successful and unsuccessful approaches for dealing with them and an agenda for the future. *Injury Prevention, 12*(supplement 1), i4-8.
Zider, S. (1979). *Development of procedures for the driver training of individuals with moderate mental retardation (Unpublished doctoral dissertation).* University of Illinois at Urbana-Champaign,