A review of the literature on male driver risk factors

A report for the Road Safety Authority of Ireland

The RSA has commissioned this synthesis of the evidence that investigates the processes implicated in the involvement of male drivers in road traffic collisions (RTCs). Identifying risk factors for RTCs presents an opportunity to intervene to prevent their occurrence and the associated burden for individuals and communities.

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Executive summary

E.1 Background

Road traffic collisions (RTCs) are one of the primary causes of death and serious injury globally. The World Health Organisation (WHO) estimates that approximately 1.3 million people are killed in RTCs annually, with the numbers being injured or suffering life changing disabilities being many multiples of this number (WHO, 2018). As a global trend, male drivers are over-represented in RTC statistics, with young male drivers a demographic of particular concern.

To put this into context, the World Health Organisation (WHO, 2022) estimates that about three quarters (73%) of all RTC fatalities are among young males under the age of 25 and that this cohort is 3 times more likely to die in a RTC as females in the same age group. This resonates with the epidemiological data from Ireland where 74% of those who died in RTCs in 2021 were male, and of drivers killed, 72% were male[1]. Moreover, a high proportion of drivers killed on Irish roads were under the age of 25 (27 of 137 fatalities in 2021 were under the age of 25; RSA, 2022).

Despite extensive theory and research in the area, there is an absence of recent syntheses of the literature on the processes implicated in a) gender and b) gender and age as risk factors for RTCs, injuries and fatalities. Such a synthesis has the potential to guide policy, practice, and future research. Against this backdrop, the Road Safety Authority of Ireland (RSA) has commissioned this synthesis of the evidence. The central aim of the review is to synthesise the literature exploring the factors which influence male driver risk of involvement in road traffic collisions. The specific review questions that guided the review are:

A) What behavioural, personality, attitudinal, or situational factors are implicated in RTCs among male road users?

B) What factors are specifically implicated in young male driver collision risk?

E.2 Method

This paper presents a Rapid Evidence Assessment (REA) of the literature regarding risk factors for RTCs involving male drivers. REA is an approach that is more systematic than a traditional literature review. It seeks to harness the systematic approach of the systematic review but tends to be less exhaustive in terms of search coverage (i.e., the breadth of the search terms and number of platforms searched). Before commencing the review, an initial review of the literature was completed (i.e., a 'scoping process'). We used this initial review to prepare a technical document (i.e., a 'review protocol') that set out the review objectives, review questions, search syntax and the platforms and databases to be included in the REA. This technical document was finalised in consultation with the Research Department of the RSA. The outcomes of interest in the review were a) rates of involvement in RTCs b) fatalities from RTCs, c) injuries from RTCs. We also included as outcomes of interest collisions in simulated environments. The types of studies eligible for inclusion in this review were cross sectional studies, cohort studies, case control studies and experimental/quasi experimental studies.

[1] Collision data for 2021 are provisional and subject to change.

The searches were carried out between 8th of May 2022 and 10th of May 2022. We systematically searched for literature that reported on RTCs involving males only or that presented data on negative outcomes across gender (i.e., males and females). We searched a total of 12 electronic databases (including Scopus, PsychINFO, OVID, ProQuest) using a search syntax. For example, Table E1 presents an the search syntax used to search PsychInfo.

Table E1

Search syntax use to search PsychInfo database

PsychInfo
Male* OR M#n OR Masculine) AND (Driv* OR Road* OR User OR Car OR Motor* OR Passenger OR simulat*) AND (perception* OR Personalit* OR sensation seeking OR Situation* OR Attitud* OR Attention* OR predict* OR Likelihood OR Behaviour*) AND (Risk* OR Danger* OR Collision OR Road Traffic Collision* OR RTC OR Speed* OR Crash* OR Accident* OR Serious Injury OR Injury OR Death OR Fatalit*

To be eligible for the review studies had to adopt one of the aforementioned study designs and be published in English since 2012. We excluded opinion pieces, newspaper/magazine articles, blogs, and studies where no primary data was available. Studies where it was not possible to differentiate between male/female specific risk factors were excluded. Studies which did not examine human risk factors related to male driver risk were excluded. Studies which did not report how human risk factors influenced our pre-specified outcomes of interest (RTC involvement, injury, death) were also excluded.

E.3 Findings

36 studies were identified which met the inclusion/exclusion criteria for this review. A total of seven categories or themes were developed that capture the range of risk factors emerging from the synthesis:

1. Personality and RTCs
   Five studies examined the influence that personality factors might have on male driving risk. Studies tended to focus on a narrow band of traits that could be theoretically linked to risk-taking and including anxiety, aggression, extroversion, impulsivity, sensation seeking, normlessness, anger and altruism (e.g. Stanojević et al., 2020; Starkey et al., 2016; Tokko et al., 2019). The literature focusing solely on male drivers reported associations between collision risk and extraversion, neuroticism (Starkey et al., 2016), aggression (Stanojević et al., 2020) and excitement seeking (Tokko et al., 2019). When male and female drivers with a history of RTCs were compared, collision risk was associated with anger, altruism and normlessness for both genders, but the relationships between sensation seeking and normlessness and RTCs was more pronounced for males. Broadly, the results indicate that personality factors that encourage impulsive decision making (non-deliberate decision making) appear to be implicated in male risk of experiencing an RTC.

2. Risky driving style and RTCs
   The results indicate that male drivers are more likely to engage in a range of risky driving practices (e.g., driving without a license) and to have prior history of driving

offences compared to females. This finding is in line with previous research, both in terms of risk-taking in general (Támas et al., 2019; Pawlowski, Atwal, & Dunbar 2008) and in relation to driving in particular (Cestac, Paran & Delhomme 2011; Rhodes & Pivik 2011), where males have been shown to take more risks than females.

3. Speeding and RTCs
   Three studies examined the relationship between speeding and crash risk in male drivers. While a small cohort of studies, the results generally indicated that male drivers were more likely than female drivers to select higher speeds or inappropriate speed for the driving conditions (Hove et al., 2020), to have been speeding at time of collision (Romano et al., 2021) and have a prior history of speeding offences, including previous collisions (Jorgenrud et al., 2018; Stephens et al., 2017). Authors have proposed a number of reasons for these findings, including that young male drivers have a greater propensity for speeding due to thrill seeking/sensation seeking (e.g., Smorti 2014).

4. Substance misuse and RTCs
   Ten studies examined alcohol, prescription medication or recreational illicit drugs, and their influence on male driver risk. The overall results of these studies suggest that the use of any substance had a negative impact on male driver safety and risk of collision, injury, or death on the road. The synthesis suggests that not only are men more likely to drink and drive than females, but they are also more likely to have a higher blood alcohol concentration (BAC) level at time of crash, and suspected greater levels of impairment. These results are in line with previous research in the field, which report that males are more likely to engage in drink-driving than females (Oh, Vaughn, Salas-Wright et al., 2020) and have unusually high BAC levels when detected (e.g., Jones & Harding, 2013).

5. Sleep, fatigue and RTCs
   Five studies investigated the relationship between driving while fatigued and male driver risk. The synthesis suggests that driving while fatigued was a significant contributor to RTCs involving male drivers. In addition to the obvious risk of falling asleep at the wheel, male driver risk appears to be exacerbated by slower reaction times resulting in less effective crash avoidance in fatigued male drivers. These results are largely in line with research that has not explicitly focused on collisions and which reported that males are more likely to engage in drowsy driving than females (Wheaton et al., 2013; Wheaton et al., 2014). The specific reasoning for increased risk for males is unclear but may relate to the fact that men are much more likely to be involved in late night or irregular shift work, which negatively impacts sleep and associated wakefulness body rhythms (Higgins et al., 2017; Wickwire et al., 2017).

6. Distracted driving and RTCs
   Five studies examined the role of distraction in RTCs involving male drivers. Four of these studies investigated the role of mobile phone use specifically while the final study looked at inner cognitive distraction (e.g., day-dreaming). The studies examining mobile phone use found that both texting and handheld phone calls were particularly risky behaviours for male drivers. Male drivers who sent/read text

messages were at much greater risk of being involved in a collision compared to other male drivers who did not engage in these behaviours. In another study, males appear to be more likely to engage in inner cognitive distractions such as daydreaming, which again appeared to be associated with greater risk of involvement in an RTC (Qin et al., 2019). Authors have attributed gender differences in driver distraction to the possibility that males perceive less severe probability of collision, and severity of consequences of a collision, and thus are less risk-avoidant behind the wheel and more likely to engage in distracted driving (e.g., Carter et al., 2014; Cordellieri et al., 2016).

7. ADHD and RTCs
   Two studies examined the link between ADHD and involvement in RTCs. In one sample of male motorcyclists, higher scores on the hyperactivity/impulsivity sub-scale of the Connor's Adult ADHD Rating Scale was associated with an increased risk of involvement in an RTC (Sadeghi-Bazargani et al., 2015).In a second study males with a diagnosis of ADHD were 1.42 times more likely to be involved in an RTC than males without an ADHD diagnosis. For females the effect was smaller, with those with a diagnosis of ADHD 1.25 times more likely to be involved in a collision (Curry et al., 2017). Overall, results suggest that ADHD traits were associated with a higher risk of involvement in RTCs for male drivers and male drivers of motorcyclists.

8. Driver Age and RTCs
   In addition to exploring correlates of RTCs, injuries and fatalities in male samples, and comparing male and female samples, some studies also reporting findings relevant to our understanding of how risk varies across the life-span. Here our primary focus was on the extent to which young male drivers were at risk of negative outcomes on the road. Six studies presented data of relevance here. Overall, the evidence synthesised suggests that the risk factors relevant to collision risk among male drivers in general are particularly salient for young male drivers. Different explanations have been proposed for this trend including the role of excitement and sensation seeking (Cestac et al., 2011), aggressive driving styles ((Ozkan & Lajunen et al., 2005) and the use of drugs and alcohol in this cohort (Wilsnack et al., 2018). Separate to our examination of young male drivers, we noted that risk of RTCs among drivers aged 70 and older may be linked to cognitive decline and medical events.

E.4 Summary of findings

The evidence is clear that risk of involvement in an RTC is greater for male drivers than female drivers. However, most of the studies eligible for inclusion here did not control for exposure – the duration spent on the road, the kms travelled, that commercial drivers are typically male etc. Such research is important as it would provide more sensitive estimates as to what extent RTC risk is linked to gender vs exposure.

The evidence is also clear that the risk of involvement in RTCs is greater for young male drivers than other drivers. That young male drivers are a demographic at particularly high risk of RTCs is in line with the broader literature on risk taking in young adults. Within this demographic (both males and females), the greatest risk to health is self-inflicted injuries caused by accidents, including RTCs, drug and alcohol misuse and violence (e.g. Blum &

Nelson-Mmari, 2004). The compelling theoretical explanation for risk taking in this demographic integrates biological, psychological and social risk processes. Steinberg (2008) provides one useful example.

He argues that the spike in risk-taking during adolescence and young adulthood arises due to increases in reward sensitivity during this period. This reward sensitivity has a biological basis - the remodelling of dopaminergic neural pathways and increases in oxytocin receptors that encourage us towards salient emotional experiences that are experienced as rewarding (e.g., excitement) and is much more pronounced in males than females. This drive for emotional reward leads to sensation-seeking and which may translate into risky behaviour. The extent to which reward sensitivity translates into sensation seeking and risk taking is modulated, in turn, by a range of factors which might include traits (personality), the presence of peers, and the presence of other disinhibitory mechanisms (e.g., drugs and alcohol) etc. Others have suggested alternative biological processes, but the with same overall formulation of risk – biological processes in adolescence create the foundation of risk-taking in this period, with the level of risk-taking influenced by a series of dispositional factors (e.g., personality) and situational factors (e.g., normative influence of peers).

Steinberg concludes that the failure to acknowledge the central role of biological processes in risk-taking among young adults has led to 'false leads' in public health approaches to reducing risk. He points to the large body of evidence suggesting that educational programmes, often delivered at great cost, have had little effect on a range of risk-taking behaviours including risky sexual behaviour, drug and alcohol misuse and reckless driving. These interventions, he concludes, may successfully change knowledge, but this does not translate into behaviour. Rather than attempting to push against the closed door of biologically-driven risk-taking by changing attitudes, he argues, the focus should be on deterring or incapacitating such behaviour.

Strategies such as raising the price of cigarettes, more vigilantly enforcing laws governing the sale of alcohol, expanding adolescents' access to mental health and contraceptive services, and raising the driving age would likely be more effective in limiting adolescent smoking, substance abuse, pregnancy, and automobile fatalities than attempts to make adolescents wiser, less impulsive, or less short-sighted. Some things just take time to develop, and mature judgment is probably one of them (p.19).

There are two important limitations of Steinberg's argument, however. First, he appears to discount the value of educational programmes that can have small, but meaningful, changes on behaviour (nudge gains). Specifically, he ignores a large volume of research on other forms of challenging behaviour that suggests that programmes that are designed to meet the needs and risk profile of the target audience, and delivered in a format to which the audience is receptive, can work in changing behaviour. Second, he ignores the fact that where such programmes draw attention to the real-world costs and consequences of risk-taking, they do exactly what he proposes in deterring risk-taking.

Separate to our examination of young male drivers, we noted findings suggesting that increased risk of an RTC was linked to cognitive decline and medical events in those aged 70 or older. This was not central to our review and was not considered in detail.

E.5 Recommendations

Returning to Steinberg's formation of risk, while his assertion that education does not change behaviour is inconsistent with some of the evidence showing reductions in risk that can arise though education, it is nonetheless the case that such reductions are often modest at best in terms of reducing negative outcomes like injury and death. Even modest gains justify such programmes. They can be enhanced, however, when offered as part of an integrated system of measures that collectively attempt to mitigate risk through different mechanisms of behaviour change. Steinberg suggests deterrence and incapacitation of risk is likely to be most effective, but he, and others, offer little guidance as to how, specifically, deterrence and incapacitation can be harnessed. Determining the detail of the different facets of this integrated system of measures is the challenge confronted by road safety agencies.

Where road safety programmes are evidence-based, then this 'detail' is determined based on a sophisticated understanding of risks and needs of high-risk road users, as well as the various strategies that may be available to reduce this risk. On the former, it is worth considering the science of health behavioural change and the Risk-Needs-Responsivity approach to mitigating risk. This approach proposes that for any intervention or prevention programme to work, it must be sensitive to the level of *risk* the audience presents, their *needs* in terms of the processes that should be targeted in the programme and be delivered in a way that is acceptable to the audience and does not elicit a negative (rebound) response (*responsivity*).

E.5.1 Understanding risk, needs and responsivity

In terms of risk, and as noted above, we have a sense that male drivers are at greater risk of involvement in RTCs, but we are less clear to what extent this increased risk is due to exposure (e.g., Kms travelled) or gender *per sae*. Primary research comparing involvement in RTCs across gender, controlling for exposure factors, would help inform primary prevention work and the narrative around male drivers. Where gender effects, disregarding age, suggest that gender is low risk (i.e., gender differences are primarily due to exposure), then this might lead to a conclusion that targeted interventions for male drivers in general is not appropriate (unlikely to bring about meaningful change, and potentially running the risk of rebound effects). Precise estimation of risk is important, and ideally these estimates would be specific to the Irish driving context, potentially based on road collision data held by the RSA and augmented by additional evidence, existing and commissioned. What is required is data on the relative odds of male drivers experiencing a RTC (vs. female drivers), and young male drivers experiencing a RTC (vs. other cohorts of drivers), having controlled for exposure effects. Higher effects would point towards the value of more complex (and resource-heavy) interventions. Lower effects may suggest that such complex interventions are unwarranted.

In terms of needs, a formulation of sorts has been presented here for young male drivers that is informed by the evidence presented in the 36 studies included in the synthesis. This provides some leads as to the set of risk factors that may be implicated in RTCs, and how these risk-factors converge and interact in a more complex process. This is a tentative formulation, however, and additional research is required to assess the needs of male drivers, and young male drivers. This could include additional qualitative (e.g., Delphi study) and quantitative (e.g., questionnaires/surveys) research.

Finally, in terms of responsivity, there is a real risk that targeting any specific driver demographic (including older drivers) could have rebound effects where an intervention or programme becomes either ineffectual or counter-productive due to its rejection by that

audience. It is possible that a novel programme (e.g., media campaign) might be lauded by a large demographic but be rejected by the very audience being targeted. Involving male drivers as stakeholders at all stages in the design and evaluation of novel programmes will be important and ensure that the target audience is responsive to the content and mode of delivery.

E.5.2 Strategies

Notwithstanding the importance of developing strategies for reducing risk in male and young male drivers organically and informed by risk, needs and responsivity, we acknowledge that there is a wide range of strategies currently deployed by road safety agencies to enhance road safety. Some of these are the types of educational programmes and media campaigns that Steinberg and others have criticised as being largely ineffective in changing risk-taking behaviour in adolescence, but are actually more likely to have small yet meaningful impacts on this driver population. Many such programmes are supported or delivered by the RSA, and to the extent that they are tailored to the target audience in terms of risks, needs and responsivity, then they should work.

But such programmes do need to be augmented by complementary strategies that deter or actively prevent (incapacitate) risk. Again the RSA has harnessed these fulcra of change, including with faster routes to disqualification for novice drivers. It is for the Agency to look at the overall suite of strategies available and select those most likely to be fruitful in the Irish context. We have not reviewed all the options available as our review focused of risk processes, rather than risk mitigation. This said, during our review we noted increased opportunities for the real-time monitoring of drivers (both in-vehicle and road-side based) which, when paired with severe sanctions, can deter risk-taking on the roads – and can incentivise safe driving. We also note that as in-vehicle technologies evolve, there will increasingly be opportunities for these technologies to identify high-risk driving and intervene to return the performance of vehicles to within safe parameters. These strategies incapacitate risky driving are being discussed as potentially valuable contributions to reducing risk on our roads.

E.6 Conclusions

This rapid evidence review sought to examine factors that contribute to the high risk of collision, injury and death faced by male drivers around the world. A secondary objective was to examine whether this male driver risk varied according to the age of the male driver. The review identified a number of distinct risk factors for male drivers that appear to be related to increased risk of involvement in an RTC. Overall, however, the synthesis points to multiple interacting risk factors that converge to increase risk. Risk, in this form, is best viewed as a complex process and risk factors as potential pinch-points for intervention. Novel programmes must be sensitive to the principles of risk, needs and responsivity and include male drivers as key stakeholders in the design process. Research on risk, needs and responsivity will be required to inform these programmes. These recommendations are made independent of the programmes currently offered by the RSA which were not reviewed as part of this report.

1. Background

Road traffic collisions (RTCs) are one of the primary causes of death and serious injury globally. The World Health Organisation (WHO) estimates that approximately 1.3 million people annually are killed in RTCs, with the numbers being injured or suffering life changing disabilities being many multiples of this number (WHO, 2018). Official statistics for the Republic of Ireland indicate that drivers constitute the majority of road fatalities, representing 70 deaths of a total of 137 deaths (51%) on Irish roads in 2021.

Extensive research has been conducted to understand the processes that lead to RTCs. Developing a body of evidence on these processes presents road safety stakeholders with specific pinch-points for interventions including in relation to driver education, public health campaigns and targeted initiatives for high-risk road users. Central to this endeavour is answering the questions: Who is at high-risk of involvement of RTCs and; what are the risk factors or processes involved?

Research has provided answers to the first question – Specifically, within the demographic profile of those involved in RTCs two key characteristics emerge. First, male drivers are at greater risk on the road than female drivers. Second, younger drivers are more at risk that older drivers. In addition, however, there emerges an interaction effect between age and gender, with young male drivers particularly over-represented in RTCs, and RTC-related injury and fatality.

To put this into context, the World Health Organisation (WHO, 2022) estimates that about three quarters (73%) of all RTC fatalities are among young males under the age of 25 and that this cohort is 3 times more likely to die in a RTC as females in the same age group. This resonates with the epidemiological data from Ireland where 74% of those who died in RTCs in 2021 were male, and of drivers killed, 72% were male[2]. Moreover, a high proportion of drivers killed on Irish roads were under the age of 25 (27 of 137 fatalities in 2021 were under the age of 25; RSA, 2022) and young males aged 18-24 report the highest prevalence rates of involvement in RTCs in the previous 12 months (4.3%, compared to 3.8% of females of females in the same age category) (Central Statistics Office, 2019).

Understanding why young male drivers are at greater risk of RTC-related injuries and fatalities is a less straight forward endeavour. This said, some explanations have been put forward focusing particularly on exposure risk and driving behaviours. Focusing on male drivers in general (i.e., not necessarily young male drivers), some authors have argued that male drivers have greater exposure to RTCs than females due to spending more time on the road (i.e., travelling more kilometres per annum; e.g., Santos et al., 2011). However, exposure alone does not explain the over-representation of males in collision statistics and other explanations have been proffered including that males and are more likely to a) over-estimate their driving abilities (Martinussen, Moller & Prato 2017; Mathews et al., 1986) and b) engage in dangerous driving behaviours including speeding, drink-driving and driving while using a mobile phone (e.g. Navas, Martin-Perez & Petrova 2019; Li et al., 2016).

Another theory proposes that men and women differ in their assessment of the consequences of risky behaviour. Cordellieri and colleagues (2016), for example, report that

[2] Collision data for 2021 are provisional and subject to change.

while males and females assessment of risk was approximately equivalent, males were less concerned about the potential impact of an RTC caused by risky driving.

In relation to young male drivers, these road users are hypothesised to be potentially at greater risk than other drivers due to being more likely than other drivers to drive while intoxicated, to speed on the roads, to drive while distracted, and to make errors in judgement while driving (e.g. Rolison et al., 2018, Oxely et al., 2014; Mcknight and Mcknight, 2003; Ozkan & Lajunen 2006). The root cause of these dangerous behaviours, some have argued, resides in the development of the pre-frontal cortex of the human brain which happens earlier in young females compared to young males (Perry et al., 2021). The pre-frontal cortex is the area that is responsible for attention, impulse inhibition, and other functions central to deliberate action (Rossi et al., 2009; Kim & Lee 2011). Theoretically, this leaves young male drivers at greater risk of impulsive behaviour, sensation and excitement seeking, and errors in action that arise from poor impulse control (i.e., a tendency to think fast, act fast and fall hard; see Arain et al. 2013). Others have linked risk taking among young males to increases in reward sensitivity during this period. This reward sensitivity has a biological basis - the remodelling of dopaminergic neural pathways and increases in oxytocin receptors that encourage us towards salient emotional experiences that are experienced as rewarding (e.g., excitement and sensation seeking activities) and is much more pronounced in males than females.

Despite extensive theory and research in the area, there is an absence of recent syntheses of the literature on the processes implicated in a) gender and b) gender and age as risk factors for RTCs, injuries and fatalities. Such a synthesis has the potential to guide policy, practice, and future research. Against this backdrop, the RSA has commissioned this synthesis of the evidence. The central aim of the review is to synthesise the literature exploring the factors which influence male driver risk of involvement in road traffic collisions. The specific review questions that guided the review are:

A) What behavioural, personality, attitudinal, or situational factors are implicated in RTCs among male road users?

B) What factors are specifically implicated in young male drivers?

2. Methods

2.1 Approach

This paper presents a Rapid Evidence Assessment (REA) of the literature. REA seeks to harness the systematic approach of the systematic review but tends to be less exhaustive in terms of search coverage (i.e., the breadth of the search terms and number of platforms searched). Before commencing the review, an initial review of the literature was completed (i.e., a 'scoping process'). We used this initial review to prepare a technical document (i.e., a 'review protocol') that set out the central aim of the review, the review questions, search syntax and the platforms and databases to be included in the REA. This technical document was finalised in consultation with the Research Department of the Road Safety Authority of Ireland.

2.2 Outcomes of interest

The outcomes of interest in the review are a) rates of involvement in RTCs b) fatalities from RTCs, c) injuries from RTCs. We also included collisions in simulated environments as outcomes of interest.

2.3 Risk Factors

The review focuses on 'human factors' as they relate to risk. Such human factors include the following:

1. Cognitive function (e.g., attention, perception, memory, reasoning, risk/hazard perception and decision making).
2. Performance (e.g., rule-based vs. knowledge based, rule violation, risk taking).
3. Error (e.g., tendency to make mistakes, lapses and slips).
4. Skills and behaviour (e.g., awareness of situations, driving skills, speed, and accuracy).
5. Personality and emotion.

2.4 Criteria for considering studies for this review

2.4.1 Types of studies

We focused our review on studies that explored risk factors for RTCs using any of the following quantitative study designs:

1. Cross-sectional, with participants retrospectively reporting a history of RTCs (outcome) and self-reporting on potential risk factors for RTCs.
2. Cohort studies, both prospective and retrospective. In the prospective design, a cohort of individuals is followed over time and later categorised as having been involved in a collision or not. Baseline measures of risk are used as the measure of risk and collision involvement/injuries/fatalities as the outcome. In a retrospective cohort study risk factors are measured retrospectively in a group of individuals who have been involved in an RTC.
3. Case-control studies where those who have been involved in a RTC are compared to those who have not had that outcome, and then either retrospectively or concurrently examined to explore human factors that may be associated with risk.
4. Experimental/quasi experimental studies including studies where a driving simulator is used to examine the relationship between human factors and crash risk.

To be eligible for the review studies had to adopt one of the aforementioned study designs and be published in English since 2012. We excluded:

1) Opinion pieces, newspaper/magazine articles, blogs, and studies where no primary data was available.
2) Studies where it was not possible to disaggregate data for male and female road users.
3) Studies that did not measure human factors as correlates or predictors of RTCs
4) Studies that did not report on involvement in RTCs, injuries or fatalities as outcomes of interest.

2.4.2 Types of participants

The participants of interest were male drivers. Some studies may compare risks across groups (e.g., males vs females, those involved in an RTC vs those not in an RTC) however in those cases findings in relation to male drivers were extrapolated where possible. Where appropriate and the data allows, male was contrasted with equivalent female data.

2.4.3 Outcome measures

Collision, injury and fatality risk were based on the following type of measures:

1. Self-report history of RTC involvement.
2. Data from official sources, including road safety agencies and the police.
3. RTC outcomes from simulated environments (e.g., driving simulators).

Where studies report on these outcomes, but also other road safety behaviours (e.g., speeding, drink driving and other violations) we prioritised RTC involvement in our synthesis but may also refer to findings in relation to violations for completeness.

2.5 Search methods for identification of studies

The searches were carried out in May 2022.

2.5.1 Electronic platforms and databases

The electronic platforms and databases listed in Table 1 were searched:

Table 1 *Search platforms and databases*

Platform	Database
ProQuest	International Bibliography of the Social Sciences
ProQuest	Dissertations and Theses Global
ProQuest	Social Sciences Premium
OVID	PsycArticles
OVID	PsycExtra (grey literature)
OVID	PsycInfo
ISI Web of Science	Web of Science Core Collection* 1. Social Sciences Citation Index (SSCI) –2010-present 2. Conference Proceedings Citation Index- Social Science & Humanities (CPCI-SSH) –2010-present

	3. Book Citation Index– Social Sciences & Humanities (BKCI-SSH) -- 2010-present
Scopus	
PubMed	
EBSCO	Academic search complete

These platforms and databases were selected as they provide coverage of journal articles across a range of publishers and disciplines, as well as indexing unpublished grey literature and academic theses. The search syntax was tailored for each search engine, searches based on the title, abstract keywords, and subject indexing fields (see Table 2 for examples).

TABLE 2 *Example of search synthesis*

Scopus	(Male* OR M#n OR Masculine) AND (Driv* OR Road* OR User OR Car OR Motor* OR Passenger OR simulat*) AND (perception* OR Personalit* OR sensation seeking OR Situation* OR Attitud* OR Attention* OR predict* OR Likelihood OR Behaviour*) AND (Risk* OR Danger* OR Collision OR Road Traffic Collision* OR RTC OR Speed* OR Crash* OR Accident* OR Serious Injury OR Injury OR Death OR Fatalit*) AND PUBYEAR > 2011
PsycINFO	(Male* OR M#n OR Masculine) AND (Driv* OR Road* OR User OR Car OR Motor* OR Passenger OR simulat*) AND (perception* OR Personalit* OR sensation seeking OR Situation* OR Attitud* OR Attention* OR predict* OR Likelihood OR Behaviour*) AND (Risk* OR Danger* OR Collision OR Road Traffic Collision* OR RTC OR Speed* OR Crash* OR Accident* OR Serious Injury OR Injury OR Death OR Fatalit*) Limit >2011

2.5.2 Searching other resources

We hand-searched leading road safety and accident prevention journals covering issues published since April 2021. This is because there can be a time-lag between publication and indexing on search platforms.

We examined past systematic reviews to identify any relevant papers and also reviewed the bibliography sections of the included papers (i.e., reverse citation chaining). We also searched for papers that cite papers included, using the 'citing articles' function on search engines where available (i.e., forward citation chaining).

2.5.3 Selection and applying exclusion criteria

At Title/Abstract screening we excluded records based on the following criteria:

a. The record is a duplicate of another paper
b. The record was published in 2011 or before
c. The record is not about road safety
d. The record is not about male driver road traffic collisions OR injuries OR fatalities

e. The record is not in English
f. The record is not for a quantitative study

Records with an answer of 'YES' to any of the above criteria were excluded. If the record was screened as 'unsure', it was included in our full-text review.

The full texts of records retained following title/abstract screening were reviewed. The same criteria as outlined above were used to exclude papers at this stage of the process.

2.5.4 Extraction

Data extraction was conducted using an *Extraction Form*. We extracted the following information:

Author, publication, year of publication, title of paper, jurisdiction, objective, study design, sample design, description of sample (age/gender), comparator group if case-control, human factors included, results and conclusions reached.

2.6 Data synthesis

The data was narratively synthesised, with the pre-specified aim of exploring key themes within the literature regarding the processes implicated in RTCs involving male road users. Given the heterogeneity of risk factors emerging during the initial scoping exercise and the rapid nature of this evidence review, it was decided that we would not seek to combine findings through meta-analysis to estimate overall effect sizes. For clarity of reporting, the synthesised results of the included studies were grouped together under the following overarching themes which account for male driver risk:

1) Personality
2) Risky driving style and RTC risk
3) Speeding and RTCs
4) Substance misuse and RTCs
5) Sleep, Fatigue and RTCs
6) Distracted driving and RTCs
   ADHD and RTCs

Secondary to this review of male driver risk factors, this review sought to examine whether there existed a variance in risk factors according to age, with a focus on young male drivers.

2.7 Data extraction

Data extraction was conducted using a standardised form. The headings under which data extraction were performed were decided *a-priori*. Two extraction tables were completed (See Tables 3 and 4, pp. 29-51). Table 3 includes the following: Authorship details, publication source, article title, jurisdiction where the research was completed, objective of the study, study design, sample of interest, comparator group (if applicable). Table 4 includes the following extraction headings; human risk factors examined, how these factors were measured, results reported and study conclusions.

In our synthesis we have sought to report both significance values and effect sizes for the studies. However, the quality of reporting is variable in the studies included in the review and it was not always possible to report these data.

3. Results

3.1 Description of studies

Figure 1 (PRISMA flowchart) depicts the results of the systematic search and screening process conducted for the REA. The search identified 20,939 individual records, restricted by date (2012 to 2022), across all sources listed in the Methods section. The records were exported to the reference manager software (EndNote V.20). As we were drawing on records from multiple platforms and databases, a large number of duplicate records/references were anticipated. 3,469 duplicate records were identified and removed using the automated functionality in the Endnote software (i.e., a process referred to as 'de-duplication'), leaving 17,470 records for Title and Abstract screening. During this screen, 17,295 records were removed as not meeting our eligibility criteria (most were excluded as not relating to road safety) with 175 papers retained for full-text review. The full texts for these records were obtained, reviewed, and screened as eligible or ineligible. 139 papers were excluded, with 36 papers meeting all eligibility criteria and included in the synthesis below.

3.2 Description/Characteristics of included studies

The characteristics of the included studies are summarised in Tables 3 and 4 (pp. 29-51). Full references are provided in the reference section at the conclusion of this review. The included studies were all published between 2012 and 2022.

3.2.1 Jurisdictions

Studies were conducted in 21 countries. Nine studies were conducted in the USA, with Iran and China representing the second most common countries of origin with three papers each. Two studies each were conducted in Saudi Arabia, Australia, and Norway. One study was conducted in each of the following countries: United Arab Emirates, Jordan, France, Taiwan, Pakistan, South Korea, Italy, India, Denmark, Colombia, Turkey, Serbia, New Zealand, Estonia, and Germany.

3.2.2 Study designs

The vast majority of included studies utilised a cross sectional design (k = 25) - e.g., studies where the authors examined police databases of crashes, injuries, or fatalities to examine possible factors which contributed to these incidents. The remaining studies were either experimental/quasi experimental (k= 6), cohort (k =4) (i.e., follows a group or groups over time) or case control (k =1) designs (i.e., a form of observational study where two groups may be compared over time without intervention from a researcher). 24 studies compared risk factors for RTCs across gender.

3.2.3 Sample size

The combined samples size for all included studies in this review is N = 186,940 drivers.

3.2.4 Sample characteristics (including age)

A full breakdown of study demographics and details is available in Table 3, in the appendix of this report.

3.2.5 Outcomes of interest

As expected from the scoping exercise, studies examined a wide range of risk factors. This included speed choice (k=3), driver distraction (k=4), sleep deprivation/driver fatigue (k=5), driver age and experience (k=4), a tendency to take risks in general (k=8), personality traits (k=6), substance use (alcohol, illegal drugs, prescription medication) (k=10), ADHD and mental health (k=3).

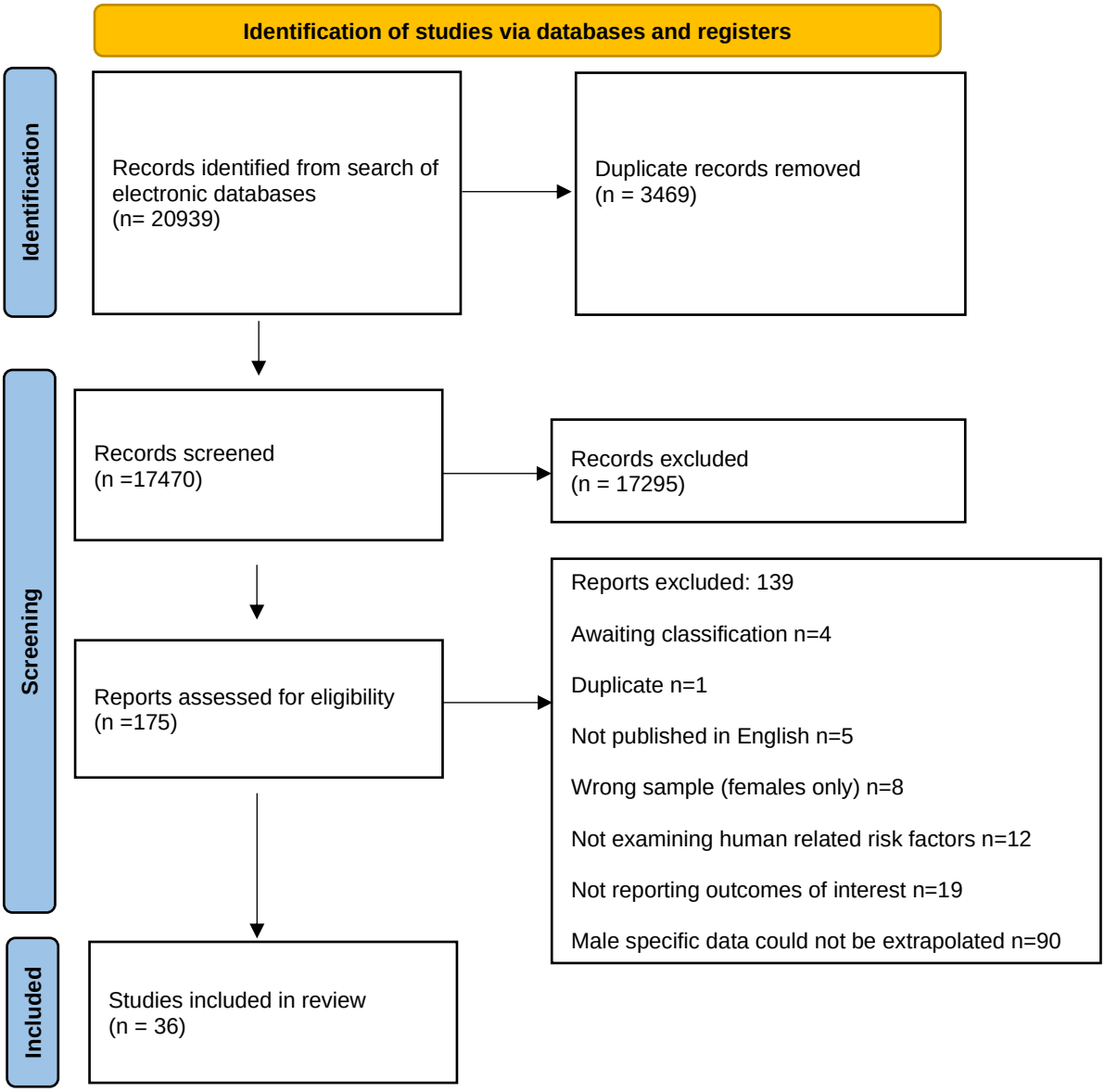

FIGURE 1: *PRISMA flow diagram*

3.3 Synthesis

3.3.1 Personality

Five studies examined the association between personality traits and risk of involvement in an RTC, including RTC leading to injury or fatality (Pourabdian et al., 2013, Stanojevic et al., 2020, Starkey et al., 2016, Tokko et al 2019, and Yang et al., 2013). There is remarkable heterogeneity in personality traits investigated across the studies with studies examining trait anxiety (Pourabdian et al., 2013), aggression (Stanojevic et al., 2020), extroversion (Starkey et al., 2016), impulsivity (Tokko et al 2019), sensation seeking, normlessness, anger, and altruism (Yang et al., 2013).

Starkey et al.s' *(2016)* study of 46 adolescent male drivers in New Zealand compared those who had been involved in a collision in the past (n=8) and those who had not. Those who had no history of an RTC had lower levels of extraversion (p=.02) and higher neuroticism (p=.002) than those who had experienced an RTC, though the difference in scores across the groups were small (extraversion, no RTC group median = 32.0, RTC group median = 35; neuroticism, no RTC group median = 34.0, RTC group median = 29) and the sample size was small. While the authors do not theorise as to the role of extraversion and neuroticism in RTC risk, the broader risk-taking literature has reported that those high in extraversion may be more prone to excitement and sensation seeking. Those low in neuroticism, conversely, may have less of an aversion towards risk taking (Liu et al., 2021).

This resonates with Stanojević et al.s' (2020) findings that RTC risk (i.e. number of RTCs) in male motorcyclists (n=300)in Serbia was correlated with higher trait aggression (r=.24, p <.01), greater tendency to be attracted to motorcycles for the purpose of sensation seeking, standing out in a group and to relax (r=.30, p <.01) and self-assertiveness (r =.28, p <0.1) – factors treated by the research team as personality traits. Self-assertiveness may be linked to RTCs, the authors propose, as those higher on self-assertiveness also reported higher drug and alcohol misuse (and which are implicated in RTCs). Again, the personality variables emerging as potentially relevant appear to prime male drivers towards more extreme behaviour.

Similarly, Tokko et al.'s (2019) neurobiological examination of RTC risk among male drivers in Estonia (n=203 with history of RTCs and 211 without) noted that a history of RTCs was associated with both excitement seeking and fast-decision making – factors that are implicated in impulsive risk taking where the tendency is to act based on automatic (non-deliberate) executive functioning rather than controlled (deliberate and careful) functioning.

Some studies compared male and female drivers. Yang et al., (2013) examined the effects of personality characteristics on driving behaviour and collision involvement in a sample of 224 male and female drivers in China. Regardless of gender, the authors reported that collision involvement was associated with the following variables; Anger (r=.16, p<0.5) Altruism (r=-0.22, p<.01), normlessness (r=0.22, p<0.1) and road traffic violations (r=0.14, p<.05). Males, however, scored significantly higher than females on driving normlessness (disrespecting driving norms) and sensation-seeking, a finding which has been reported by others included in this review (i.e., Tokko et al., 2019). Moreover, males reported having more aggressive and ordinary violations (aggressive: t(222)=2.04, p=.04; ordinary: t(222)= 3.8, p < .0001). These results are in line with the results reported by Stanojević et al (2020), with personality traits such as aggressiveness implicated in negative outcomes for male drivers.

Pourabdian et al., 2013 reported on their study of 168 drivers in Iran who had been involved in a RTC. 142 of these drivers were male. They reported that trait anxiety was a positive correlate of all forms of driving violations, errors and lapses in judgement when driving, though the magnitude of the association was small for all models (r=1.5 to 2.3 for all bi-variate correlations). The authors suggest that trait anxiety influences crash risk, as those scoring higher on trait anxiety may have inhibited memory performance and be more likely to drive absent-mindedly.

In conclusion, studies comparing male and female drivers report findings that appear to suggest that that RTCs involving males may be related to aggression, impulsivity, sensation seeking and normlessness, with males scoring higher on these traits than females (in samples where all participants were involved in an RTC). It is notable that these traits also emerged as relevant in samples comprised of males only and where there was an association between these traits and risk of involvement in an RTC (i.e., where the samples had, or did not have, a history of involvement in an RTC).

3.3.2 Risky driving style and RTC risk

Eight studies reported on risky driving behaviour and its relationship with risk of being involved in a RTC (Bener at al., 2020, Davey et al., 2022. Gershon et al., 2018, Mehdizadeh et al., 2019, Moller et al., 2019b, Oviedo-Trespalacios et al., 2018, Sadeghi-Bazargani et al., 2015 & Stanojevic et al., 2020).

Mehdizadeh et al., (2019) for example, recruited a sample of 1319 male Iranian truck and taxi drivers to investigate similarities and differences of self-reported risky driving behaviour and crash involvement in professional drivers. They reported that taxi drivers who had been involved in a collision were more likely to report a range of ordinary violations (e.g., OR = 1.69, 95% CI 1.49 to 2.38) and aggressive violations (e.g., OR = 1.98, 95% CI 1.76 to 2.95). Aggressive violations, in this study, referred to hostile driving including aggressive braking and aggressive tailgating. Ordinary violations included running red lights and other forms of violations that were not characterised by hostility. In separate analyses they focused on truck drivers only and again risk of RTC was associated with reported errors while driving (OR = 1.21, 95% CI 1.09 to 1.52), more ordinary violations (OR = 1.37, 95% CI 1.17 to 1.63) and more aggressive violations (OR = 1.42, 95% CI 1.23, to 1.76). Similar results were reported by Stanojevic et al. (2020) in their study of motorcyclists in Serbia (n=206) who reported a correlation between self-reported history of road traffic violations and RTC involvement (r=.29, p<.01).

Sadeghi-Bazargani et al. (2015) compared the self-reported driving history of motorcyclists (n = 449) admitted to hospital following a collision with motorcyclists admitted for non RTC related issues. They found that higher self-assessed risky behaviour was associated with RTC involvement as measured by the Motorcycle Rider Behaviour Questionnaire's (MBRQ) Risky behaviour scale (OR=1.22, 95% CI 1.01 to1.45) (p=0.031). Similarly, using a motorcycle for recreation rather than solely commuting purposes was associated with greater risk of collision, approaching statistical significance (OR=1.85, 95% CI 0.98 to 3.46, p=0.05). Stanojevic et al., 2020, reported a similar finding, with the recreational use of a motorcycle (rather than for solely commuting purposes) was implicated in an increased risk of collision.

A number of studies compared male and female drivers and their history of road traffic offences. Bener et al., (2020) reported on risky behaviours which may influence crash risk amongst a sample of Jordanian Drivers (n=1084) who had been involved in a RTC. The results

suggest that male drivers were statistically significantly more likely than females to engage in careless driving (30% of male drivers vs 20% female drivers, p=.001) and dangerous manoeuvres such as driving through a red light (36% of male drivers vs 22.5% of female drivers, p=.006).

Davey et al., 2021, conducted a cross sectional investigation of RTCs in Queensland, Australia from 2011 to 2019 (n =1136). The analysis revealed that most drivers who were killed in a road traffic crash between 2011 and 2019 were male (82.8%) and had committed at least one relevant traffic offence in the past five years (76.8%). Males had, on average, a greater number of traffic offences (*M*= 4.71, *SD* = 5.58) in comparison to females (*M* = 2.36, *SD* = 3.64; *t* (1,134) = 5.80, *p* < .001). For example, the results showed that 94.3% of those killed on the road due to dangerous driving between 2011-2019 were males. 94.5% of all drivers who were not wearing a seatbelt at time of fatal collision were male.

Previous traffic offences were also reported as predictive in the study of Colombian drivers carried out by Oviedo-Trespalacios et al. (2018). This study (*n* =392) specifically examined gender differences in driver risk in a sample of young drivers aged 18 to 24. The results indicated that male drivers who self-reported persistent rule violations had higher odds of being involved in a RTC than females and that risk of involvement in an RTC increased with age within this group of young adults.

Gershon et al. (2018) (*n* =90) examined the difference in safe driving performance between initial accompanied driving (supervised driving, with qualified adult in the car) and independent driving (without supervision, post passing driving test and receiving full license) periods in young adults. During the initial period of independence, crash rates, regardless of gender were eight times higher overall than their rates during the final months of supervised driving (Incidence Rate Ratio (IRR) = 8.32, CI = 2.01 to 34.34). While driving without supervision, the authors reported that risky driving behaviours were higher among male than female adolescent drivers (IRR = 1.73, 95% CI 1.16 to 2.60). For both female and male adolescents, risky driving rates were three times higher the first quarter of unsupervised, independent driving compared to the last quarter of the supervised learner period. Moller et al., 2019b (*n* =274) examined collisions involving licenced and unlicenced drivers in Denmark and reported that young males were more than 4 times more likely to be involved in a collision involving an unlicenced driver than young females (OR =4.06 95% CI 1.43 to 11.60).

In summary, studies that compared male and female risky driving behaviour and the relationship of risky driving styles with RTCs, injuries or fatalities typically report that males are more likely than females to engage in careless or dangerous driving practices, more likely to have a prior history of traffic violations and are more likely to drive while unlicensed.

3.3.3 Speeding (specific concern) and RTCs

Three studies investigated driving over the speed limit as a male driver risk factor for collisions, injuries and fatalities (Hoye et al., 2020, Jorgenrud et al., 2018, Romano et al., 2021). All studies compared cohorts of male and female drivers.

Hoye et al. (2020), examined the role of speeding in fatal collisions in Norway between 2005 to 2015 (*n* =1,501). The analysis of these crash statistics indicated that male drivers were significantly more likely to have been excessively speeding (OR = 4.50, 95% CI not reported) (*p*<.05) or driving at a speed unsuitable for road conditions (OR = 1.80, 95% CI not reported) (*p*<.05) at time of crash when compared to female drivers. Jorgenrud et al. (2018) examined

the relationship between speeding and RTC involvement by conducting a cross sectional study with 5,031 Norwegian drivers. Males reported more frequent involvement in RTCs, and the accumulation of more speeding violations over the previous 2 years, than females and this was most notable in the youngest age group (16–24 years). Regardless of gender, prior speeding tickets were associated with reported involvement of RTC (OR =1.39 95 % CI 1.08 to 1.80).

A similar relationship between speeding behaviour and RTC involvement was reported by Romano et al. (2021). The authors reported on the relationship between speeding and fatal crashes among a cohort of 18–20-year-old drivers who at time of collision were not full license holders. This cross-sectional study captured incidents from 2010 to 2017 (*n* =9,676). In line with the results reported by Hoye et al. (2020) and Jorgenrud et al. (2018), males aged 18–20 were more likely to have been speeding at the time of the collision than females (OR = 1.78 95% CI 1.59 to 1.99) (*p* <.001).

The overall findings from these three studies suggest that male drivers are more likely than their female counter parts to drive over the speed limit or drive too fast for the road conditions, and that speeding is predictive of risk of involvement in an RTC.

3.3.4 Substance misuse and RTCs

Nine studies examined the link between substance use/misuse and RTCs (Booth et al., 2016, Cook et al., 2020, Hoye et al., 2020, Hsieh et al., 2017, Jorgenrud et al., 2018, Lastrucci et al., 2021, Romano et al., 2021, Sun et al., 2014, Tokko et al., 2019, Vollrath et al 2019). These studies focused on alcohol, controlled drugs, and prescription medication.

For example, Vollrath et al. (2019) conducted a study examining the effects of alcohol consumption on safe driving performance (measured in a simulator) and crash avoidance in a sample of *n*=48 German male drivers. The study comprised of two experiments, each of which involved a simple driving scenario and a more complex driving scenario (intersection manoeuvre) and with participants allocated to an experimental (alcohol consumed) or placebo (no alcohol consumed) group. Findings were inconsistent for the effects of alcohol on driving performance, with the researchers suggesting that some drivers who had consumed alcohol may have engaged in compensatory strategies (reduced speed) to reduce the risk of a collision. It is unclear to what extent a) similar compensatory strategies are deployed in the real world and b) how successful they are at mitigating collisions even if deployed.

Hoye et al., (2020) reports findings that suggest that the link between alcohol and RTCs may be more pronounced among male drivers. They examined the contributing factors implicated in 1501 fatal road collisions between 2005-2015 in Norway. Males involved in fatal collisions were 2.23 times more likely to have been under the influence of alcohol than female drivers involved in fatal collisions, a finding concordant with other studies that met our inclusion criteria (Hsieh et al., 2017, Lastrucci et al., 2021, Romano et al., 2021 and Sun et al., 2014, which are outlined below).

Booth et al. (2016) examined the relationship between prescription medication usage (Zolpidem) in older American adults (aged 70 years or older) and effects on driving risk (n= 2,000). The authors reported that while those on zolpidem were at greater risk of RTCs than non-users, (RR = 1.46 95% CI 1.02 to 2.08) no pattern emerged across gender. This finding

suggests that regardless of gender, impairment due to medication may be predictive of involvement in a crash.

Cook et al. (2020) sought to assess whether there was an increased/decreased risk of RTCs following marijuana decriminalisation in the US. This cross-sectional study examined data from 2010 to 2017 from several large cities in the US (*n* =2,496 drivers). The results indicated that the decriminalisation of marijuana was associated with an increase in fatal crashes involving males. On average, a city experienced 13% more fatal crashes involving 15- to 24-year-old male drivers following city-level marijuana decriminalisation (this equated to an average of approximately 3.5 more fatal crashes per 100 000 in 15- to 24-year-old males). In contrast no increased crash risk was observed amongst females or older male cohorts.

Overall, the synthesis suggests that the use of alcohol and/or drugs is associated with increased risk of RTCs, and that this risk is more pronounced among male drivers. Hsieh et al. (2017) and others have proposed that even where males and females engage in drink-driving, males tend to have higher blood alcohol concentrations (BACs) than females, leading to more serious collisions and longer duration in intensive care units in hospitals.

3.3.5 Sleep, fatigue and RTCs

Five studies examined the potential role of sleep deprivation on male risk of collision, injury or death while driving (Al Shareef et al., 2021, Bougard et al., 2021, Kim et al., 2021, Mahajan et al., 2021, Ozer et al., 2014).

Bougard et al. (2021) examined the relationship between sleep deprivation and crash avoidance manoeuvres of male motorcyclists using a driving simulator (n =12). Participants completed the driving tasks when rested after a normal night's sleep and when sleep deprived. Results suggested at 40kph the distance necessary to stop the powered two-wheeler simulator increased with sleep deprivation (normal night: 7.58m ± 0.20m vs Sleep Deprivation: 9.16m ± 0.39m; i.e., +21%) as did the stopping time (normal night: 0.85 ± 0.02 s vs 1.01 ± 0.22 s after SD; +19%). The increase observed in stopping time and distance when riding at 40 kph could be directly connected to the reaction part of the manoeuvre (+0.13 s, +21.4%).

The impact of sleep deprivation on reaction time was also examined in Mahajan et al. (2021). Here, the authors examined the relationship between sleep deprivation and rear end crash potential of male drivers using a driving simulator (*n* =50). The analysis produced results which were in line with the findings of Bougard et al., 2021, whereby sleep deprivation negatively reduced a driver's ability to react effectively to changing driving conditions and avoid a crash. They concluded that drivers who drive under conditions of fatigue may struggle to control their speed, resulting in difficulties with deacceleration to avoid rear-end collisions. In two trials, the magnitude of this increase in collision risk was 63% and 94% respectively.

The results presented by Bougard et al. (2021) and Mahajan et al. (2021) may explain the higher crash rates reported by Ozer et al. (2014). Ozer and colleagues (2014) explored the relationship between sleepiness, sleep habits and crash risk in male Turkish public transport drivers (*n* =320). Forty-nine (15.3%) of the 320 public drivers reported that they had at least one sleepiness related motor vehicle collisionand/or near miss collision. Group 1 (collision group) reported less sleep time per night than Group 2 (*M* =6.86hrs vs *M* =7.39hrs, *p* <.001). Logistic regression analysis of risk factors including age, body mass index, daily sleep time, driven distance per year, daytime sleepiness and, constructs of sleep habits suggested that

only daytime sleepiness increased the risk of traffic collisions (OR = 1.32, 95% CI 1.19 to 1.47) p<.001). Drivers who reported collisions also scored higher on the Epworth Sleepiness Scale, which measures daytime sleepiness, than those who did not report collision involvement. Ozer and colleagues suggest that the relationship between fatigue and collision risk may be due to depleted reaction times under conditions of sleepiness, as well as incidents of falling asleep while driving.

Al Shareef et al. (2021) included both male and female drivers in their study of the effects of day-time sleepiness and RTCs (n = 4,708). Being female significantly reduced the likelihood of both falling asleep while driving (OR = 0.14, 95% CI 0.09 to 0.22, p < 0.001) or being in a RTC or 'near miss' due to fatigue or falling asleep compared to men driving (OR = 0.20, 95% CI 0.13 to 0.33, p < 0.001). The results indicated that men (p < 0.001), individuals with a higher BMI (p < 0.001), shorter sleep duration (p <0.001), worse sleep efficiency (percentage of time spent asleep while in bed; p =0.003), and higher scores on a measure of daytime sleepiness (the Epworth Sleepiness Scale (ESS); p < 0.001) were associated with having fallen asleep while driving in the previous year. With respect to having had/nearly had an collision due to being tired or falling asleep while driving in the previous year men (p < 0.001), poorer subjective sleep quality (p < 0.001), and higher ESS (p < 0.001) were associated with increased crash risk. These findings resonate with those of Kim et al. (2021) in their investigation of fatigue-related RTCs on South Korean motorways between 2006- 2021 (n=2,972). They reported that males were more likely to be involved in such collisions than females, accounting for 91.4% of such RTCs.

Overall, the results indicate that males are at markedly increased risk of being involved in a fatigue-related RTC relative to females, though the reasons for this difference have not been fully explored in the literature to date including gender differences in shift-work, long-distance driving etc.

3.3.6 Distracted driving and RTCs

Five studies explored driver distraction as a contributory factor in RTCs involving male drivers. Four studies (Al-Jasser et al., 2018; Bendak et al., 2015; Bener et al., 2020; Li et al., 2016) examined mobile phone use and its relationship with collision risk, while the final study examined internal (cognitive) and road distractions (Qin et al., 2019).

Al-Jasser et al. (2018) examined mobile phone use while driving and the risk of collision amongst male students in Saudi Arabia (n= 986). 44.6% (n=440) of the sample reported that they had experienced a collision in the previous 6 months. 37.9% (n=167) of these collisions were attributed to the use of the mobile phone. In addition, 84.3% (n=832) reported near misses attributed to the use of mobile phones. The risk of collision was significantly higher among students who used handheld mobile phones while driving (OR = 1.46, 95% CI 1.02 to 2.09) than hands-free phones (OR = 1.11, 95% CI 0.56 to 2.15). A significantly higher risk was also observed among those who sent or read text messages either always (OR = 1.89, 95% CI 1.40 to 2.6) or once in a while (OR = 1.60, 95% CI 1.09 to 2.35) compared to those that never read text messages.

To examine how texting can influence driving behaviour and crash risk, Bendak et al. (2015) used a driving simulator to experimentally assess the processes involved (n =21). They reported that when texting participants were much more likely to cross lanes (p < 0.01) and road boundaries (p = 0.02) compared to those in the 'no text' condition. They also spent more time driving without watching the road (15 times more on average, p < 0.01). Overall,

texting while driving led, on average, to almost five times more crashes than driving without texting (p = 0.01).

Some studies included both male and female drivers. Bener et al. (2020) examined the factors which contribute to crash risk in Jordan (n =1,084). The results suggested that male drivers who were involved in a crash were significantly more likely than females to have been texting at time of collision (p =0.41). Findings from Li et al. (2016) suggest that males may have poor compensatory behaviours relative to females when driving while using their mobile phones, with females leaving a greater distance between their own and other vehicles when using a mobile phone and also performing better on deceleration tasks in emergency situations**,** indicating poor compensatory behaviour on behalf of male drivers.

Distraction in general seems to affect male drivers more than female drivers. Qin et al. (2019) reported mixed results however suggesting that young drivers are more likely to be distracted by in-vehicle technologies than older drivers, young females are more likely to be distracted by these technologies than young male drivers, and males are more likely to be distracted by internal cognitive distractions (e.g., daydreaming, mind wandering, losing focus on task at hand) and distraction by external stimuli (such as signs, road events, instrumentation inside the vehicle) than females.

The synthesis suggests that males are less likely to engage in compensatory behaviour to offset their reduced ability to react to road events while using a mobile phone. Overall, in the studies examining mobile phone use, these results indicate that significant impairment in driving performance is caused by texting while driving, and that increased crash risk may arise due to an increased likelihood of crossing lanes, road boundaries and an impaired ability to react to changing road conditions. Aside from mobile phone use, males are more likely to engage in cognitive distractions, like daydreaming or mind wandering, and on road distractions compared to female drivers. In summary, males seem to be more likely to use mobile phones while driving, have a higher propensity to daydream while driving, and are less effective at employing strategies to reduce the risk posed by engaging in these distractions.

3.3.7 ADHD and RTCs

Two studies examined Attention Deficit Hyperactivity Disorder (ADHD) as a predictor of male driver risk of RTCs (Curry et al., 2017 & Sadeghi-Bazargani et al., 2015).

Sadeghi-Bazargani et al. (2015) found that higher scores on the hyperactivity/impulsivity sub-scale of the Conner's Adult ADHD Rating Scale were associated with increased risk of involvement in an RTC among motorcyclists (OR = 1.13 95% CI 1.04 to 1.23) ($p<0.005$). Gender differences emerged in a second study. Curry et al. (2017) found that males with ADHD were 1.42 times more likely to be involved in an RTC than males without an ADHD diagnosis (95% CI 1.28 to 1.56). The effect was less pronounced among female drivers, where those with an ADHD diagnosis were 1.25 times more likely to be involved in a collision (95% CI 1.08 to 1.45). Regardless of gender, a diagnosis of ADHD equated to a 36% increased risk of RTC involvement.

3.3.8 Driver age and RTCs

Seven papers included in this review reported on age as a risk factor for male driver collision injury or death (Adanu et al.,2021; Cicchino et al., 2015; Cook et al., 2020; Javid et al., 2022; Mehdizadeh et al., 2019; Pourabdian et al., 2019; Yan et al., 2021). The picture emerging across these studies is that younger drivers are at greater overall risk of being involved in RTCs, and young male drivers are at greatest risk.

Yan et al. (2021), for example, conducted a temporal analysis of crash severity involving male and female drivers (*n*= 65,409). They reported that age, alcohol use and lack of insurance are predictors of collisions regardless of gender but that younger male drivers are the most at-risk group in the studied population. Similar finding were reported in Adanu et al. (2021). Javid et al., (2022) and Mehdizadeh et al.s' (2019) studies. In the latter study of male professional drivers, increasing age was negatively associated with RTC involvement (OR = 0.77, 95% CI 0.66 to 0.91). There is some evidence in their data that younger drivers are more likely than older drivers to have a history of ordinary and aggressive violations, through older drivers may be more error prone. As noted earlier, in this study, ordinary violations refer to intentional rule-violating driving behaviour, such as driving through a red light. Aggressive violations refer to hostile actions directed to another driver which may include aggressive tailgating, aggressive braking, flashing lights, aggressive use of horn and other intimidatory/road rage behaviours etc.

Cook et al. (2020) examined the impact that marijuana decriminalisation had on fatal road traffic collisions in the United States. Two ages groups were specifically examined in the analysis, 15–24-year-olds and 25–44-year-olds. Again, the results indicated that male drivers in t he older age group were less likely to be involved in a RTC than younger drivers after decriminalisation.

Finally, there is some evidence in these studies that the processes leading to RTCs may vary across the lifespan. Cicchino et al. (2015) report results suggesting that drivers in the US aged 70+ are more likely to experience an RTC arising from a medical event (RR = 2.18, 95% CI 1.13 to 4.21) or due to an illegal manoeuvre (defined by the authors as; failure to obey traffic controls, turning from the wrong lane, and turning with an obstructed view) (RR = 3.56 95% CI 1.38 to 9.19) than those aged 35-44.. This is in-line with results from Mehdizadeh et al.s' (2019) study which suggested that while younger drivers are more likely than older drivers to have a history of intentional rule-violating behaviour and aggressive violations (intimidatory acts/road rage behaviours), older drivers may be more error-prone.

The evidence presented above would suggest that young male drivers are at particular risk of collision, injury or death while driving. This increased risk may be attributed to more aggressive, impulsive behaviour or a greater likelihood of driving while impaired. While age appears to be a protective factor, with risk decreasing with age, the oldest male drivers appear to have elevated risk due to medical events or increased propensity for engaging in illegal manoeuvres such as failure to obey traffic rules, turning from the wrong lane etc.

4. Discussion

4.1 Summary of main results

The 36 studies eligible for inclusion in the review are remarkably heterogenous in terms of study design, driver samples recruited (e.g., professional and non-professional drivers), geographic location and culture (e.g. China, Iran and the US) and human factors of interest. This heterogeneity has provided a broad picture of some of the risk factors and processes that might be implicated in RTCs for male drivers (and young male drivers). However, there is a lack of depth in the body of evidence – the depth that emerges when multiple studies focus on a narrow band of risk factors, testing replicability across driver populations and probing the processes through which risk factors confer increased risk of RTCs. That said, some conclusions can reasonably be reached based on the synthesis.

First, and focusing on personality and individual differences, findings point to the role of personality traits associated with sensation seeking, impulsivity, anger, normlessness and aggression in RTCs involving male drivers and young male drivers in particular (e.g., Starkey et al., 2016; Stanojević et al., 2020; Yang et al., 2013; Sadeghi-Bazargani et al., 2015). These traits can contribute to a broader risk profile that leads to increased involvement in road traffic violations and RTCs (e.g., Tokko et al., 2019; Mehdizadeh et al., 2019 Oviedo-Trespalacios et al., 2018). The findings are in line with a separate body of evidence that has linked risky driving among young male drivers to the development of the pre-frontal cortex of the brain over the course of the lifetime. This section of the brain is responsible for planned and deliberate behaviour and appears to reach maturity towards the late 20s and may do so later for males. It is also compatible with evidence on increases in reward sensitivity during adolescence and deriving from the remodelling of dopaminergic neural pathways and increases in oxytocin receptors that encourage us towards salient emotional experiences that are experienced as rewarding (e.g., excitement and sensation seeking) and which is much more pronounced in males than females (e.g., Steinberg, 2008). While we did not conduct a meta-analysis of the studies on personality included in the review, looking across the studies the effects appear to be consistent, significant but small. That is, personality does not, alone, offer a lot of explanatory value in explaining why male drivers, and young male drivers in particular, are at increased risk of RTCs.

Larger effects were reported for some forms of risky driving and in particular speeding. The results are consistent here, with male drivers selecting higher speeds, or more excessive speeds, compared to females (Hove et al., 2020; also, Stephens et al., 2017) and with speeding implicated in collisions (Jorgenrud et al., 2018; Romano et al., 2021).

There is also some consistency in the findings relating to drink-driving. Here the evidence is unanimous in reporting that alcohol impairs driving and increases risk of involvement in RTCs (Vollrath et al., 2019). The effect is common to both male and female drivers. However, the evidence suggests that male drivers are more likely to drink and drive and to have higher BAC levels when tested following an RTC (Hove et al., 2020; Hsieh et al.,2017; Lastrucci et al., 2021; Romano et al., 2021; Sun et al., 2014; & Tokko et al., 2019). The synthesis, then, suggests that drink driving is more prevalent among male drivers, that they consume more alcohol prior to driving and are more incapacitated than female drivers, e incapacitating , though additional research is needed to determine the validity of this finding for the Irish context.

Patterns also emerged for driving while impaired due to fatigue and for driving while using a mobile phone. In relation to driving while fatigued, again the evidence would suggest that, regardless of gender, driving while impaired due to tiredness increases risk of involvement in an RTC. However, male drivers are more likely to drive when fatigued (Kim et al., 2021; Shareef et al., 2021), which is in-line with the broader literature (Wheaton et al., 2013; Wheaton et al., 2014), and the effects here were significant and large, with males 10 times more likely to be in a fatigue-related RTC than females in Kim et al.s' (2021) study. There is some evidence that males are slow to adopt compensatory strategies to manage their fatigue when driving (Mahajan et al., 2021) which may explain, in part at least, the effects reported. It has also been suggested, however, that males are much more likely to be involved in late night or irregular shift work, which negatively impacts sleep and associated wakefulness body rhythms (Higgins et al., 2017; Wickwire et al., 2017) and may help explain differences across gender.

For mobile phone use and driver distraction, males were reported to be more likely to use a mobile phone and text from their phones while driving than females (Bener et al., 2020). Again, in comparison to females, males were less likely to engage in compensatory behaviours to manage risk, such as increasing the distance to the car ahead (Li et al., 2016). Some have suggested that males are more likely to drive while distracted than females because they perceive the risks and consequences of being involved in a collision as being less severe (e.g., Carter et al., 2014; Cordellieri et al., 2016).

Finally, the evidence does support the assertion that young male drivers are particularly at risk of RTCs. This increased risk may be attributed to more aggressive and hostile driving styles, including improper lane changing (Adanu et al., 2021), reckless driving (e.g. chasing another car to remonstrate with the driver; Mehdizadeh et al.,2019) greater likelihood of driving after drinking alcohol or drugs (Wilsnack et al., 2018), driving while otherwise impaired (Cook et al., 2020; Yan et al., 2021) and engaging in other forms of risky driving behaviours (Cestac et al., 2011; Javid et al., 2022; Ozkan & Lajunen et al., 2005). Separate to our examination of young male drivers, we noted that risk of RTCs among drivers aged 70 and older may be linked to cognitive decline and medical events. As our review was primarily concerned with male (and young male) drivers, we did to consider this finding in detail or male recommendations in relation to older drivers.

4.2 Take-home overarching findings

The evidence is clear that risk of involvement in an RTC is greater for male drivers than female drivers. However, most of the studies eligible for inclusion here did not control for exposure – the duration spent on the road, the kms travelled, that commercial drivers are typically male etc. Such research is important as it would provide more sensitive estimates as to what extent RTC risk is linked to gender vs exposure.

The evidence is also clear that the risk of involvement in RTCs is greater for young male drivers than other drivers. That young male drivers are a demographic at particularly high risk of RTCs is in line with the broader literature on risk taking in young adults. Within this demographic (both males and females), the greatest risk to health is self-inflicted injuries caused by accidents, including RTCs, drug and alcohol misuse and violence (e.g. Blum & Nelson-Mmari, 2004). The compelling theoretical explanation for risk taking in this

demographic integrates biological, psychological and social risk processes. Steinberg (2008) provides one useful example.

He argues that the spike in risk-taking during adolescence and young adulthood arises due to increases in reward sensitivity during this period. This reward sensitivity has a biological basis - the remodelling of dopaminergic neural pathways and increases in oxytocin receptors that encourage us towards salient emotional experiences that are experienced as rewarding (e.g., excitement) and is much more pronounced in males than females. This drive for emotional reward leads to sensation-seeking and which may translate into risky behaviour. The extent to which reward sensitivity translates into sensation seeking and risk taking is modulated, in turn, by a range of factors which might include traits (personality), the presence of peers, and the presence of other disinhibitory mechanisms (e.g., drugs and alcohol) etc. Others have suggested alternative biological processes, but the with same overall formulation of risk – biological processes in adolescence create the foundation of risk-taking in this period, with the level of risk-taking influenced by a series of dispositional factors (e.g., personality) and situational factors (e.g., normative influence of peers).

Steinberg concludes that the failure to acknowledge the central role of biological processes in risk-taking among young adults has led to 'false leads' in public health approaches to reducing risk. He points to the large body of evidence suggesting that educational programmes, often delivered at great cost, have had little effect on a range of risk-taking behaviours including risky sexual behaviour, drug and alcohol misuse and reckless driving. These interventions, he concludes, may successfully change knowledge, but this does not translate into behaviour. Rather than attempting to push against the closed door of biologically-driven risk-taking by changing attitudes, he argues, the focus should be on deterring or incapacitating such behaviour.

Strategies such as raising the price of cigarettes, more vigilantly enforcing laws governing the sale of alcohol, expanding adolescents' access to mental health and contraceptive services, and raising the driving age would likely be more effective in limiting adolescent smoking, substance abuse, pregnancy, and automobile fatalities than attempts to make adolescents wiser, less impulsive, or less short-sighted. Some things just take time to develop, and mature judgment is probably one of them (p.19).

There are two important limitations of Steinberg's argument, however. First, he appears to discount the value of educational programmes that can have small, but meaningful, changes on behaviour (nudge gains). Specifically, he ignores a large volume of research on other forms of challenging behaviour that suggests that programmes that are designed to meet the needs and risk profile of the target audience, and delivered in a format to which the audience is receptive, can work in changing behaviour. Second, he ignores the fact that where such programmes draw attention to the real-world costs and consequences of risk-taking, they do exactly what he proposes in deterring risk-taking.

4.3 Recommendations

Returning to Steinberg's formation of risk, while his assertion that education does not change behaviour is inconsistent with some of the evidence showing reductions in risk that can arise though education, it is nonetheless the case that such reductions are often modest at best in terms of reducing negative outcomes like injury and death. Even modest gains justify such programmes. They can be enhanced, however, when offered as part of an integrated system of measures that collectively attempt to mitigate risk through different mechanisms of

behaviour change. Steinberg suggests deterrence and incapacitation of risk is likely to be most effective, but he, and others, offer little guidance as to how, specifically, deterrence and incapacitation can be harnessed. Determining the detail of the different facets of this integrated system of measures is the challenge confronted by road safety agencies.

Where road safety programmes are evidence-based, then this 'detail' is determined based on a sophisticated understanding of risks and needs of high-risk road users, as well as the various strategies that may be available to reduce this risk. On the former, it is worth considering the science of health behavioural change and the Risk-Needs-Responsivity approach to mitigating risk. This approach proposes that for any intervention or prevention programme to work, it must be sensitive to the level of *risk* the audience presents, their *needs* in terms of the processes that should be targeted in the programme and be delivered in a way that is acceptable to the audience and does not elicit a negative (rebound) response (*responsivity*).

4.3.1 Understanding risk, needs and responsivity

In terms of risk, and as noted above, we have a sense that male drivers are at greater risk of involvement in RTCs, but we are less clear to what extent this increased risk is due to exposure (e.g., Kms travelled) or gender *per sae*. Primary research comparing involvement in RTCs across gender, controlling for exposure factors, would help inform primary prevention work and the narrative around male drivers. Where gender effects, disregarding age, suggest that gender is low risk (i.e., gender differences are primarily due to exposure), then this might lead to a conclusion that targeted interventions for male drivers in general is not appropriate (unlikely to bring about meaningful change, and potentially running the risk of rebound effects). Precise estimation of risk is important, and ideally these estimates would be specific to the Irish driving context, potentially based on road collision data held by the RSA and augmented by additional evidence, existing and commissioned. What is required is data on the relative odds of male drivers experiencing a RTC (vs. female drivers), and young male drivers experiencing a RTC (vs. other cohorts of drivers), having controlled for exposure effects. Higher effects would point towards the value of more complex (and resource-heavy) interventions. Lower effects may suggest that such complex interventions are unwarranted.

In terms of needs, a formulation of sorts has been presented here for young male drivers that is informed by the evidence presented in the 36 studies included in the synthesis. This provides some leads as to the set of risk factors that may be implicated in RTCs, and how these risk-factors converge and interact in a more complex process. This is a tentative formulation, however, and additional research is required to assess the needs of male drivers, and young male drivers. This could include additional qualitative (e.g., Delphi study) and quantitative (e.g., questionnaires/surveys) research.

Finally, in terms of responsivity, there is a real risk that targeting any specific driver demographic could have rebound effects where an intervention or programme becomes either ineffectual or counter-productive due to its rejection by that audience. It is possible that a novel programme (e.g., media campaign) might be lauded by a large demographic but be rejected by the very audience being targeted. Involving male drivers as stakeholders at all stages in the design and evaluation of novel programmes will be important and ensure that the target audience is responsive to the content and mode of delivery.

4.3.2 Strategies

Notwithstanding the importance of developing strategies for reducing risk in male and young male drivers organically and informed by risk, needs and responsivity, we acknowledge that there is a wide range of strategies currently deployed by road safety agencies to enhance road safety. Some of these are the types of educational programmes and media campaigns that Steinberg and others have criticised as being largely ineffective in changing risk-taking behaviour in adolescence, but are actually more likely to have small yet meaningful impacts on this driver population. Many such programmes are supported or delivered by the RSA, and to the extent that they are tailored to the target audience in terms of risks, needs and responsivity, then they should work.

But such programmes do need to be augmented by complementary strategies that deter or actively prevent (incapacitate) risk. Again the RSA has harnessed these fulcra of change, including with faster routes to disqualification for novice drivers. It is for the Agency to look at the overall suite of strategies available and select those most likely to be fruitful in the Irish context. We have not reviewed all the options available as our review focused of risk processes, rather than risk mitigation. This said, during our review we noted increased opportunities for the real-time monitoring of drivers (both in-vehicle and road-side based) which, when paired with severe sanctions, can deter risk-taking on the roads – and can incentivise safe driving. We also note that as in-vehicle technologies evolve, there will increasingly be opportunities for these technologies to identify high-risk driving and intervene to return the performance of vehicles to within safe parameters. These strategies incapacitate risky driving are being discussed as potentially valuable contributions to reducing risk on our roads.

4.4 Conclusions

This rapid evidence review sought to examine factors that contribute to the high risk of collision, injury and death faced by male drivers around the world. A secondary objective was to examine whether this male driver risk varied according to the age of the male driver. The review identified a number of distinct risk factors for male drivers that appear to be related to increased risk of involvement in an RTC. Overall, however, the synthesis points to multiple interacting risk factors that converge to increase risk. Risk, in this form, is best viewed as a complex process and risk factors as potential pinch-points for intervention. Novel programmes must be sensitive to the principles of risk, needs and responsivity and include male drivers as key stakeholders in the design process. Research on risk, needs and responsivity will be required to inform these programmes. These recommendations are made independent of the programmes currently offered by the RSA which were not reviewed as part of this report.

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Table 3 – Extraction table: Study details

Author	Publication	Year	Title	Jurisdiction	Objective	Design	Sample	Comparator (if applicable)
E. K. Adanu, A. Lidbe, E. Tedla and S. Jones	Accident Analysis and Prevention 2021 Vol. 149	2021	*Factors associated with driver injury severity of lane changing crashes involving younger and older drivers*	USA	This study investigates the risk factors that are associated with driver injury severity of unsafe lane changing crashes	Cross sectional	Younger drivers (defined as at-fault driver age less than 25 years based on the authors' experiential knowledge of crash patterns involving drivers in this age category in Alabama) or older drivers (defined as at-fault driver aged 65 years and older based on the National Highway Traffic Safety Administration (NHTSA) definition of older drivers	NA
F. S. Al-Jasser, A. G. Mohamed, A. Choudry and R. M. Youssef	Journal of Family and Community Medicine 2018 Vol. 25 Issue 2 Pages 102-107	2018	*Mobile phone use while driving and the risk of collision: A study among preparatory year students at King Saud University, Riyadh, Saudi Arabia*	Saudi Arabia	The aim of the study was to determine the rate of mobile use while driving, by university students: their perception of the risks of this behaviour, and its contribution to collisions.	Cross sectional	986 male students at King Saud University, Riyadh, Saudi Arabia. The highest percentage of students were 19 years old (64.5%) while the rest were 18 years old (8.0%) or 20–23 years old (27.5%).	NA
S. M. Alshareef	Sleep and Breathing 2021 Vol. 25 Issue 3 Pages 1671-1676	2021	*Excessive daytime sleepiness and associations with sleep-related motor vehicle accidents: results from a nationwide survey*	Saudi Arabia	The objective of this study was to investigate how sleep quality and excessive daytime sleepiness (EDS) affect falling asleep while driving and sleep-related collisions & near-misses	Cross sectional	4679 Participants (4071 Male participants) Participants aged 18 years and older were randomly selected from the Saudi Telecom Company database, which covers all 13 Saudi provinces	Female Drivers
S. Bendak	International Journal of Injury Control and Safety Promotion 2015 Vol. 22 Issue 4 Pages 387-392	2015	*Objective assessment of the effects of texting while driving: a simulator study*	UAE	The objective of this study was to assess the level of detrimental impact that texting while driving has on key driving performance indicators	Quasi-experimental	21 "young" male drivers. The average age of the 21 participants was 22.3 years (*SD* = 1.5; min 20; max 25) with an average driving experience of 3.6 years (*SD* = 1.5; min 0.5; max 6)	NA
A. Bener, K. Jadaan, D. Crundall and A. Calvi	International Journal Of Crashworthiness 2020 Vol. 25 Issue 3 Pages 276-283	2020	*The effect of aggressive driver behaviour, violation, and error on vehicle crashes involvement in Jordan*	Jordan	The objective of this study was to examine the effect of aggressive driver behaviour, violation and error on motor vehicle crashes and investigating the factor structure of the Driver Behaviour Questionnaire (DBQ)	Cross sectional	A representative sample of 1450 Jordanian drivers was selected from both males and females aged 22 years and above. Males n=778	Female Drivers

					factors on the crash involvement in Jordan			
J. N. Booth, M. Behring, R. S. Cantor, L. D. Colantonio, S. Davidson, J. P. Donnelly, et al.	Sleep Medicine 2016 Pages 98-102	2016	*Zolpidem use and motor vehicle collisions in older drivers*	USA	Aim of study was to evaluate possible effect of sleep medication on RTCs	Cross sectional	Participants were current drivers aged ≥70 years residing in north-central Alabama, spoke English, had a valid driver's license, and drove within the past 3 months (n=2,000)	Zolpidem user's vs nonusers + Male/Female comparisons
C. Bougard, D. Davenne, S. Moussay and S. Espié	Journal of Safety Research 2021 Vol. 78 Pages 36-46	2021	*Evaluating sleep deprivation and time-of-day influences on crash avoidance manoeuvres of young motorcyclists using a dynamic simulator*	France	The aim of this study was to evaluate the influences of time-of day and sleep deprivation on two different crash avoidance manoeuvres, namely emergency braking and swerving, performed on a dynamic motorcycle simulator	Quasi-experimental	Twelve healthy young males (age: 22.9 ± 1.9 years old; height: 177.6 ± 7.5 cm; weight: 79.2 ± 13.2 kg) particular attention was paid to motorcycling experience (participants held a motorcycling license for 3.8 ± 2.6 years) and to the participant's chronotype (person's circadian typology, reflecting morning and evening preferences	NA
J. B. Cicchino and A. T. Mccartt	Accident Analysis and Prevention 2015 Vol. 80 Pages 211-219	2015	*Critical older driver errors in a national sample of serious U.S. crashes*	USA	The purpose of this study was to examine older driver errors in serious crashes in order to determine which errors are most prevalent.	Cross sectional	A nationally representative sample of 5470 U.S. police reported passenger vehicle crashes during 2005–2007 for which emergency medical services were dispatched. There were 620 crashes involving 647 drivers aged 70 and older, representing 250,504 crash involved older drivers.	Younger drivers (35-54) vs older drivers >70
A. C. Cook, G. Leung and R. A. Smith	American Journal of Public Health 2020 Vol. 110 Issue 3 Pages 363-369	2020	*Marijuana decriminalization, medical marijuana laws, and fatal traffic crashes in US Cities, 2010-2017*	USA	The aim of this study was to determine the impact of city-level cannabis decriminalization and Medical marijuana laws on fatal traffic crashes in US cities.	Cross sectional	N =2496 semi-annual city-level observations from several cities in the United States	Male vs Female – age groups 15-24yo, 25-44yo
A. E. Curry, K. B. Metzger, M. R. Pfeiffer, M. R. Elliott, F. K. Winston and T. J. Power	JAMA Paediatrics 2017 Vol. 171 Issue 8 Pages 756-763	2017	*Motor vehicle crash risk among adolescents and young adults with attention-deficit/hyperactivity disorder*	USA	To examine the association between ADHD and both driver licensing and crash involvement and whether it varies by sex, licensing age, and/or being prescribed ADHD medication at licensure	Cohort study	Cohort of 2479 adolescents and young adults with ADHD and 15865 without ADHD who were (1) born from 1987 to 1997; (2) residents of New Jersey and patients at 1 of 6 New Jersey primary care practices at age 12 years or older; and (3) age-eligible to obtain a driver's license from 2004 through 2014 Male n = 9330 (50.9%)	ADHD diagnosed individuals vs Non ADHD diagnoses individuals

B. Davey, A. Parkes, J. Freeman, L. Mills and J. Davey	Journal of Safety Research 2022	2022	*Versatile, but not focused, traffic offenders are more likely to be at fault for a fatal crash*	Australia	The aim of this study was to determine whether drivers who had received more traffic infringements were more likely to be at fault for the crash in which they were killed	Cross sectional	Total of 1,136 government-coded crash records were examined in which the driver of at least one involved vehicle was fatally injured Of these, 931 of deceased drivers were male (77.8%) and 207 were female (22.2%). The sample ranged in age between 16 and 96 years (M = 43.73; SD = 19.27)	Males vs Females
P. Gershon, J. P. Ehsani, C. M. Zhu, K. R. Sita, S. Klauer, T. Dingus, et al.	JOURNAL OF ADOLESCENT HEALTH 2018 Vol. 63 Issue 5 Pages 568-574	2018	*Crash Risk and Risky Driving Behavior Among Adolescents During Learner and Independent Driving Periods*	USA	The objectives of this study were to examine the variability in measures of driving risk among adolescents during the learner and early independent driving periods and evaluate how risk varies by driving experience, gender, time of day, and road surface conditions.	Cohort	The novice adolescent drivers' group included 49 females and 41 males with an average age of 15.6 years (SD = .2) A total of 217 Crash/Near Crash (CNC) (148 near crashes and 69 crashes with 9 police-reported crashes), 2.4 (SD = 3.0) per driver, The adult drivers' group consisted of 63% female drivers, mean age 47.5 (SD = 6.3), with mean driving experience of 31.3 years (SD = 6.4), Adult drivers had 112 CNCs (84 near crashes and 28 crashes with 2 police-reported crashes), an average of 1.2 (SD = 1.7) per driver.	Adolescent vs “Experienced Drivers” / Males vs Females
A. Høye	Traffic Injury Prevention 2020 Vol. 21 Issue 7 Pages 425-430	2020	*Speeding and impaired driving in fatal crashes—Results from in-depth investigations*	Norway	The aim of the study was to identify typical patterns of risk factors among speeding and impaired drivers involved in fatal crashes and to suggest countermeasures.	Cross sectional	1,501 fatal passenger car crashes that occurred in Norway from 2005 to 2015 and involved 1,949 passenger cars	Males vs Females
C. H. Hsieh, S. Y. Hsu, H. Y. Hsieh and Y. C. Chen	Biomed J 2017 Vol. 40 Issue 2 Pages 113-120	2017	*Differences between the sexes in motorcycle-related injuries and fatalities at a Taiwanese level I trauma center*	Taiwan	The aim of this study was to investigate and compare the injury patterns, injury characteristics, and mortality of male and female patients hospitalized for treatment of motorcycle collision-related trauma in a level I trauma centre.	Cross sectional	4028 male and 2919 female patients hospitalized for treatment between January 1, 2009, and December 31, 2013	Males vs Females
M. A. Javid, N. Ali, M. Abdullah, T. Campisi, S. A. H. Shah and S. Suparp	Infrastructures 2022 Vol. 7 Issue 2	2022	*Analysis of Driver’s Socioeconomic Characteristics Relating to Speeding Behavior and Crash*	Pakistan	To assess socioeconomic characteristics predictive of speeding and crash involvement	Cohort	N=551 (Males n=457). Pakistani drivers	NA

			Involvement: A Case Study in Lahore					
B. Jørgenrud, S. T. Bogstrand, H. Furuhaugen, R. E. G. Jamt, V. Vindenes and H. Gjerde	Traffic Injury Prevention 2018 Vol. 19 Issue 8 Pages 779-785	2018	*Association between speeding and use of alcohol and medicinal and illegal drugs and involvement in road traffic crashes among motor vehicle drivers*	Norway	The objective of this study was to study the association between self-reported road traffic crashes and recent use of alcohol, medicinal and illicit drug use, and self-reported speeding in the previous 2 years	Cross sectional including bio sample analysis	5031 volunteer Norwegian drivers stopped at police checkpoints	Males vs Females
S. Kim and C. Oh	Journal of Transportation Safety and Security 2021 Vol. 13 Issue 1 Pages 93-107	2021	*Freeway crashes involving drowsy driving: Crash characteristics and severity in South Korea*	South Korea	This study aimed to examine driver, vehicle, road, weather, and temporal characteristics associated with drowsy-driving crashes in South Korea	Cross sectional	2,972 drowsy-driving crashes were analysed for this study (Crashes in South Korea between 2006 - 2021	Males vs Female
V. Lastrucci, F. Innocenti, C. Lorini, A. Berti, C. Silvestri, M. Lazzeretti, et al.	International Journal of Environmental Research and Public Health 2021 Vol. 18 Issue 12	2021	*Profiles of risky driving behaviors in adolescent drivers: A cluster analysis of a representative sample from Tuscany region (Italy)*	Italy	This study has three specific aims: First, to evaluate the prevalence of risky driving behaviours (RDBs) in a representative population-based sample of adolescent drivers of the Tuscany Region, Italy and to identify clusters of drivers that share similar patterns of RDBs. Second, if clusters of RDBs are present, to identify sociodemographic, mental and social well-being, and risky behaviours variables associated with cluster membership. Third, to evaluate the differences in the risk of RTCs across RDB clusters.	Cross sectional	N= 2162 Italian Students (Male n= 1473)	Males vs Females
X. Li, X. Yan, J. Wu, E. Radwan and Y. Zhang	Accident Analysis and Prevention 2016 Vol. 97 Pages 1-18	2016	*A rear-end collision risk assessment model based on drivers' collision avoidance process under influences of cell phone use and*	China	This study investigate the manner and extent to which cell phone use and driver's gender affected driving performance and collision risk in a rear-end collision avoidance process	Quasi-experimental	A total of 42 subjects (21 males and 21 females). With an age range of between 30 – 40 years old	Males vs Females

			gender—A driving simulator-based study					
K. Mahajan and N. R. Velaga	Accident Analysis and Prevention 2021 Vol. 156	2021	*Sleep-deprived car-following: Indicators of rear-end crash potential*	India	This study aimed to measure the effects of partial sleep deprivation on driver safety during car-following	Quasi-experimental	53 Males, aged between 18–50 years, with mean 8.74 years (±5.88 years) of holding a valid driving licence.	NA
M. Mehdizadeh, A. Shariat-Mohaymany and T. Nordfjaern	Transportation Research Part F: Traffic Psychology and Behaviour 2019 Vol. 62 Pages 86-98	2019	*Driver behaviour and crash involvement among professional taxi and truck drivers: Light passenger cars versus heavy goods vehicles*	Iran	The aim of the study was to investigate similarities and dissimilarities of risky driving behaviour and crash involvement between passenger car drivers and truck drivers. Secondarily, this study examined the factor structure of risky driving behaviour between these two types of professional drivers.	Cross sectional	All male sample comprised of Iranian Professional drivers N= 1319: Truck drivers n= 914 Taxi drivers n=405	NA
H. Mőller, K. Rogers, P. Cullen, T. Senserrick, S. Boufous and R. Ivers	Journal of Epidemiology and Community Health 2021 Vol. 75 Issue 8 Pages 755-763	2021	*Socioeconomic status during youth and risk of car crash during adulthood. Findings from the DRIVE cohort study*	Australia	The aim of this study was to investigate if drivers living in areas of low Social Economic Status (SES) as young adults have a higher risk of car crash during adulthood compared with drivers from areas of high SES and if these differences vary by gender and crash characteristics.	Cross sectional	Data from a 2003/2004 Australian survey of young drivers (n=20 806), which included measures of drivers' demographics and established crash risk factors	Males vs Females
M. Moller and K. H. Janstrup	Accident Analysis and Prevention 2021 Vol. 156	2021	*Crash involvement among unlicensed 17-year-old drivers before and after licensing at 17 was allowed*	Denmark	This paper aims to examine whether crash involvement among 17-year-old unlicensed drivers changed after post-licence accompanied driving from the age of 17 was allowed in Denmark in 2017	Cross sectional	Data from 274 car crashes, involving a 17-year-old driver between 2014-2019 in Denmark	Males vs Females
O. Oviedo-Trespalacios and B. Scott-Parker	Traffic Injury Prevention 2018 Vol. 19 Issue 1 Pages 9-17	2018	*The sex disparity in risky driving: A survey of Colombian young drivers*	Colombia	The aim of the research was to explore sex differences in self-reported risky driving behaviours of young drivers, including the associations with crash-involvement, in a sample of young drivers attending university in Colombia	Cross sectional	"young" Colombian drivers, N = 392 (of which 255 were Male), aged 16-24 attending university.	Males vs Females

C. Ozer, S. Etcibasi and L. Ozturk	International journal of clinical and experimental medicine 2014 vol. 7 issue 1 pages 268-273	2014	*Daytime sleepiness and sleep habits as risk factors of traffic collisions in a group of Turkish public transport drivers*	Turkey	To explore the association of daytime sleepiness, sleep complaints and sleep habits with self-reported car crashes among public transport drivers	Cross sectional	Male Turkish Professional Drivers, N =320. Mean age±SD, 40±11 years	Collision groups vs No Collision group
S. Pourabdian and H. Azmoon	International Journal of Preventive Medicine 2013 Vol. 4 Issue 10 Pages 1115-1121	2013	*The relationship between trait anxiety and driving behavior with regard to self-reported Iranian collisiont involving drivers*	Iran	The aims of this study included: Determination of the most common driver behaviour in drivers and also analysing the relationship between trait anxiety (TA) with subscale of driving behaviour (lapses, errors, ordinary and aggressive violations)	Cross sectional	168 Iranian drivers of which the majority were male n=142. The mean age was 29 years old (*SD* = 6.68) range of 19-48 years old). All participants had a driving license.	NA
L. Q. Qin, Z. X. Li, Z. J. Chen, M. S. A. Bill and D. A. Noyce	Journal of safety research 2019 Vol. 69 Pages 23-31	2019	*Understanding driver distractions in fatal crashes: An exploratory empirical analysis*	USA	The aim of this study was to assess the effects of different distractions in fatal RTCs	Cross sectional	All fatal crashes from 2010-2013 in the USA. Specifically, 13,707 distraction specific crashes.	NA
E. Romano, J. C. Fell, K. G. Li, B. G. Simons-Morton and F. E. Vaca	Drug and alcohol dependence 2021 Vol. 218	2021	*Alcohol- and speeding-related fatal crashes among novice drivers aged 18-20 not fully licensed at the time of the crash*	USA	This study aims to compares the prevalence of alcohol use and speeding among individuals aged 18–20 y/o who were not fully licensed drivers (NFLD) at the time of the fatal crash with that of their fully licensed counterparts (FLD)	Cross sectional	N=9676, Males n=7225, US residents 18-20 who died in a fatal crash as recorded by FARS system 2010-2017	Licensed driver's vs unlicensed drivers/ Males vs Females
H. Sadeghi-Bazargani, L. Abedi, M. Mahini, S. Amiri and D. Khorasani-Zavareh	Neuropsychiatric Disease and Treatment 2015 Vol. 11 Pages 2049-2054	2015	*Adult attention-deficit hyperactivity disorder, risky behaviors, and motorcycle injuries: A case-control study*	Iran	The aim of this study was to assess the association of motorcycle traffic injuries with motorcycle riding behaviour and subtypes of attention-deficit hyperactivity disorder (ADHD) while controlling for individual correlates of motorcycle traffic injuries	Case-Control	All subjects were male and aged 13–79 years, 298 for motorcycle injuries and 151 controls	Motorbike Injured patient's vs control hospitalisations
D. Stanojević, P. Stanojević, D. Jovanović and K. Lipovac	Journal of Transportation Safety and Security 2020 Vol. 12 Issue 3 Pages 400-418	2020	*Impact of riders' lifestyle on their risky behavior and road traffic collision risk*	Serbia	The main aim of the study was to determine how lifestyle dimensions of male motorcyclists influence the risky behaviour of motorcyclists and their involvement in traffic collisions.	Cross sectional	300 Male participants, with valid driver's licences.	NA

N. J. Starkey and R. B. Isler	Transportation Research Part F: Traffic Psychology and Behaviour 2016 Vol. 38 Pages 127-136	2016	*The role of executive function, personality, and attitudes to risks in explaining self-reported driving behaviour in adolescent and adult male drivers*	New Zealand	This study was undertaken to investigate the roles of executive function, personality, attitudes to risk in relation to self-reported driving behaviour.	Quasi experimental	A total of 78 male drivers were recruited for this study. Participants were assigned to one of two groups; the adolescent group, age 16–18 years (n = 46, mean age = 16.88 years, *SD* = 0.53) or the adult group, 25 years and over (n = 32, mean age = 37.91 years, *SD* = 7.55)	Adolescent drivers vs Adult drivers
Y. Sun, Z. Huang, Z. Zhao, Y. Jiang, Y. Ye, T. Yu, et al.	Traffic Injury Prevention 2014 Vol. 15 Issue 6 Pages 532	2014	*Characteristics of 1226 Alcohol-Positive Drivers Involved in Nonfatal Traffic Crashes in Shanghai, China*	China	The purpose of our study was to better characterize and evaluate drunk driving for governmental reference in order to further reduce alcohol-impaired driving.	Cross sectional	1226 alcohol-positive drivers with blood alcohol concentrations (BACs) at or over the legal limit of 0.20 mg/mL involved in nonfatal traffic collisions in Shanghai, China, from 2008 to 2011 Male n=1179	Male vs female
T. Tokko, D. Eensoo, M. Vaht, K. P. Lesch, A. Reif and J. Harro	Acta Neuropsychiatrica 2019 Vol. 31 Issue 2 Pages 84-92	2019	*Relapse of drunk driving and association with traffic collisions, alcohol-related problems and biomarkers of impulsivity*	Estonia	The primary objective of this study was to assess whether baseline markers of impulsivity, alcohol use and risk-taking behaviour have any predictive value in traffic in a 10-year time period.	Cross sectional	The group of drunk drivers comprised male subjects who were identified by the police as driving drunk at least once during the previous year (n = 203; mean age ± SD, 33±11 years) The control group consisted of 211 individuals, with a mean age of 36±12 years	Control group consisted of male subjects in the driving licence database of the Estonian Motor Vehicle Registration Centre
M. Vollrath and J. Fischer	Accident Analysis and Prevention 2017 Vol. 109 Pages 89-98	2019	*When does alcohol hurt? A driving simulator study*	Germany	To assess whether subjective assessment of the traffic situation and the adaptation of behaviour under the influence of alcohol plays a major role in collision causation	Experimental	German, male drivers N = 111 Experiment 1 n=48 Experiment 2 n=63	No alcohol control group
X. T. Yan, J. He, C. J. Zhang, Z. Y. Liu, C. W. Wang and B. S. Qiao	Analytic methods in accident research 2021 vol. 30	2021	*Temporal analysis of crash severities involving male and female drivers: A random parameters approach with heterogeneity in means and variances*	USA	this paper aims to explore the heterogeneity and temporal stability of casualty crash severity between male and female drivers	Cross sectional	Data records for all injury single-vehicle crashes occurring in California from January 1, 2013, until December 31, 2017, provided by Highway Safety Information System (HSIS)	Male vs Female
J. Yang, F. Du, W. Qu, Z. Gong and X. Sun	Traffic Injury Prevention 2013 Vol. 14 Issue 6 Pages 565-571	2013	*Effects of Personality on Risky Driving Behavior and Accident Involvement for Chinese Drivers*	China	This study aimed to examine the effects of personality variables on Chinese drivers' unsafe driving behaviours and collision involvement	Cohort	Two hundred twenty-four licensed drivers completed the questionnaires (82 males and 142 females; 37.9% aged 20–30, 46.4% aged 30–40, 15.6% aged 40–50).. One hundred sixty of the drivers (133 female, 27 male) were on-the-job graduate students (response	NA

							rate was 80%). The other drivers (9 female, 55 male) were recruited at a train station (response rate was 64%)	

Table 4 – Extraction table: study results

Title	Human Risk factors	Measurement	Results	Conclusions
Adanu et al 2021: Factors associated with driver injury severity of lane changing crashes involving younger and older drivers	Driver experience & Age	Crash data obtained from the Critical Analysis Reporting Environment (CARE) system developed by the Centre for Advanced Public Safety at the University of Alabama	The model estimation results from this study show that the male indicator variable in the younger driver model increases the likelihood of major injury by 0.025 and decreases the likelihood of minor injury and no injury by 0.0003 and 0.022, respectively. For the older driver model, male drivers had a decreased likelihood of major injury by 0.0006 and an increased likelihood of minor injury by 0.0281. Page 5	Younger male drivers were more likely to sustain a major injury in lane changing crashes than older male drivers. It was also found that older drivers were more likely to be severely injured on interstate highways than younger drivers.
Al-Jasser et al., 2018: Mobile phone use while driving and the risk of collision: A study among preparatory year students at King Saud University, Riyadh, Saudi Arabia	Distraction (Mobile phone use while driving)	"Data were collected by a self-administered questionnaire designed for the purpose of the study and tested on a sample of students not included in the study"	Collision in the 6 months before the study was reported by 44.6% (n = 440) of the students; 37.9% (n = 167) of these collisions were attributed to the use of the mobile phone. In addition, 84.3% (n = 832) reported near misses attributed to the use of mobile phones. The risk of collision was significantly higher among students who used handheld mobile phones while driving (OR = 1.460; 95% CI 1.023 to 2.087) than hands-free phones (OR = 1.110; 95% CI 0.564 to 2.145). This risk was significantly higher among students who reported that they always talked on handheld mobile phones while driving (OR = 1.435; 95% CI 1.019 to 2.037) and hands-free mobile phones either always (OR = 1.469; 95% CI 1.093 to 1.975), or once in a while (OR = 1.599, 95% CI 1.120 to 2.282). A significantly higher risk was also observed among those who sent or read text messages either always (OR = 1.885; 95% CI 1.400 to 2.537) or once in a while (OR = 1.596; 95% CI 1.085 to 2.347. Page 104	Of the participants, 44.6% reported having had collisions in the 6 months before the study and 37.9% attributed the collisions to the use of mobile phones. The risk of collision was significantly higher among participants who reported the frequent use of mobile phones whether as a handheld or hands-free devices to text and talk.
Alshareef et al., 2021: Excessive daytime sleepiness and associations with sleep-related motor vehicle accidents: results from a nationwide survey	Sleep quality and daytime sleepiness	Author created questionnaire which encompassed the Epworth Sleepiness Scale	The results found that: older individuals ($p < 0.0001$), men ($p < 0.0001$), individuals with a higher BMI ($p < 0.0001$), singletons ($p < 0.0001$), shorter sleep duration ($p < 0.0001$), worse sleep efficiency ($p = 0.003$), and higher ESS ($p < 0.0001$) were associated with having fallen asleep while driving in the previous year. With respect to having had/ nearly had an collision due to being tired or falling asleep while driving in the previous year, younger individuals ($p = 0.01$), men ($p < 0.0001$), use of sleeping medications ($p = 0.01$), poorer subjective sleep quality ($p < 0.0001$), and higher ESS ($p < 0.0001$) were associated with a negative outcome.	Being male was the strongest predictor of both falling asleep while driving (OR = 0.14 95% CI 0.09 to 0.22); $p < 0.0001$ for women compared to men) and having an collision or near miss while driving (OR = 0.20 95% CI 0.13to 0.33); $p < 0.0001$ for women compared to men), consistent with previous studies.

			With respect to having had/nearly had an accident due to being tired or falling asleep while driving in the previous year, younger age (OR = 0.98 (95% CI 0.97 to 0.99); p = 0.001), being male (OR 0.20 (95% CI 0.13–0.33); p < 0.0001), having worse subjective sleep quality (OR 2.11 (95% CI 1.36–3.29); p < 0.0001 for "very bad" sleep quality), and having moderate or severe EDS (OR 1.90 (95% CI 1.38–2.60); p < 0.0001 and OR 2.39 (95% CI 1.56–3.67); p < 0.0001) were associated with a negative outcome. Page 2	
Bendak et al., 2015 : Objective assessment of the effects of texting while driving: a simulator study	Effects of distraction (texting) on driving perfomance	Driving simulator	Overall, texting while driving led, on average, to almost five times more crashes than driving without texting (p = 0.01, x^2 = 7.64) This was reflected on town roads where the number of crashes increased due to texting from 3 crashes in 21 driving sessions to 10 and on highways where the number increased from 1 to 9 crashes. Due to distraction, participants unnecessarily crossed lane boundaries (p < 0.01) and road boundaries (p = 0.02, x^2 = 5.32) more often when driving while texting as compared to driving without texting. Distraction due to texting is also clearly demonstrated through the percentage of time drivers took their eyes off the road to look at their mobile phones and read and/or write messages (p < 0.01) eyes were off the road while texting 15 times, on average, more than without texting. Finally, drivers deviated their eyes off the road more often due to texting on highways than on town roads (p = 0.02). This may be attributed to the greater cognitive demands placed on drivers on congested town roads than on less congested highways. Page 390	Results showed that texting while driving led, on average, to five times more crashes than driving without texting. Due to distraction also, participants unnecessarily crossed lane boundaries and road boundaries more often while texting as compared to driving without texting. Moreover, distraction due to texting led to participants deviating their eyes off the road while texting 15 times per session, on average, more than without texting. Results demonstrated a high-risk level of distraction and clear impairment in drivers' ability to drive safely due to texting.
Bener et al., 2020: The effect of aggressive driver behaviour, violation, and error on vehicle crashes involvement in Jordan	Driver behaviour Driver violation Driver Error	Driver Behaviour Questionnaire (DBQ)	Male drivers who were involved in a crash were statistically significantly more likely than females to have the following as contributing factors: Careless driving (P =.001), Smoking (.001), Excessive speed (.001), Mobile phone use (P=.001) Texting (.041) dangerous manoeuvre (breaking red light) P =0.006). Page 4	Drivers who were involved in crashes were more likely to have exceeded the speed limit beforehand. The current assessment showed that driver distraction by mobile phone and using SMS text message are a contributory cause of road crashes.
Booth et al., 2016: Zolpidem use and motor vehicle collisions in older drivers	Prescription medication effect on driving (sleeping tablets – Zolpidem MVC (motor vehicle collisions)	Mini Mental State Examination (MMSE) Driving Habits Questionnaire	In the primary analysis, the unadjusted RR (95% CI) for all MVCs comparing current zolpidem users with nonusers was 1.46 (1.02 - 2.08). The sex-stratified unadjusted RRs (95% CIs) were 1.23 (0.72 - 2.09) for males. Page 10	Generally, the older the participants (>80 years) the increased likelihood Zolpidem use had on RTC involvement however there was no significant association between male gender and increased crash risk.

Bougard et al., 2021: Evaluating sleep deprivation and time-of-day influences on crash avoidance manoeuvres of young motorcyclists using a dynamic simulator	Sleep deprivation & Time-of-Day influences on crash avoidance	Simulated motorbike riding tests- a 'virtual' fall occurred (reproduced by the simulation model in the visual scene and also by vibrations in the motorcycle seat) when a rider failed to perform safely (braked too hard or overturned the bike)	A significant interaction effect between 'speed' and 'sleep condition' was observed on both the stopping distance ($F(1,22) = 8.54$; $\varepsilon = 1.00$; $p < 0.01$; partial $g2 = 0.28$) and time ($F(1,22) = 7.76$; $\varepsilon = 1.00$; $p < 0.05$; partial $g2 = 0.26$). At 20 kph, the participants stopped in a shorter distance (3.28 ± 0.26 m) and faster (0.63 ± 0.03) than at 40 kph (Fig. 5A). At 40 kph, the distance necessary to stop the PTW (normal night: 7.58 ± 0.20 m vs SD: 9.16 ± 0.39 m; +21%), and also the stopping time significantly increased with SD (normal night: 0.85 ± 0.02 s vs 1.01 ± 0.22 s after SD; +19%). As for the reaction part of the manoeuvre, a significant interaction effect between 'speed' and 'sleep condition' was observed on both the distance ($F(1,22) = 9.96$; $\varepsilon = 1.00$; $p < 0.01$; partial $g2 = 0.31$) and time ($F(1,22) = 8.08$; $\varepsilon = 1.00$; $p < 0.01$; partial $g2 = 0.27$). At 20 kph, participants reacted in a shorter distance (2.30 ± 0.25 m) and faster (0.39 ± 0.02 s) than at 40 kph. At 40 kph, the reaction distance (normal night: 6.53 ± 0.20 m vs SD 8.05 ± 0.37 m; +23%) and time significantly increased with SD (normal night: 0.62 ± 0.02 s vs SD: 0.75 ± 0.03 s; +21%. n interaction effect between 'sleep condition' and 'time-of-day' was observed on braking distance ($F(3,66) = 3.16$; $\varepsilon = 0.89$; $p < 0.05$; partial $g2 = 0.13$) and time ($F(3,66) = 3.21$; $\varepsilon = 0.83$; $p < 0.05$; partial $g2 = 0.13$). The Bonferroni post-hoc analysis reported no significant differences regarding braking distances; while braking times measured after the normal night's sleep were significantly shorter at 06:00 h than at 18:00 h (0.19 ± 0.01 s vs 0.22 ± 0.01 s; 16%). Page 5	This papers major finding is that emergency braking performance was significantly affected by lack of sleep, more particularly at 40 kph. The increase observed in stopping time and distance when riding at 40 kph could be directly connected to the reaction part of the manoeuvre (+0.13 s, +21.4%). The stopping distance and time at 40 kph were increased after SD. These worsening performances (distance: +1.58 m, +21%; time: +0.16 s, +19%) indicated that participants were not able to stop as quickly as they did after the normal night's sleep, even at quite low speeds. Further analyses indicated that these impaired performances after the sleepless night should be mainly related to increased reaction times. After the normal night's sleep, reaction times measured at 20 kph (0.39 s) and 40 kph (0.62 s).
Cicchino et al., 2015: Critical older driver errors in a national sample of serious U.S. crashes	Older driver errors 70+ (compared to younger drivers 35-54)	National Highway Traffic Safety Administration's National Motor Vehicle Crash Causation Survey	Critical errors resulting in RTC due to medical events (RR 2.18 (1.13-4.21)) and illegal manoeuvres (RR 3.56 (1.38-9.19)) occurred significantly more often among older male drivers than middle-aged male drivers. Page 216	Medical conditions such as epilepsy and diabetes are associated with increased crash risk, in part because they elevate the likelihood of sudden incapacitation. Medical events were significantly more prevalent among older men than middle-aged men with critical errors in the current study but did not differ between older and middle-aged women. The prevalence of medical events among older male drivers may be a factor in why the proportion of their errors attributed to inadequate surveillance and gap or speed misjudgement were lower than among women.

Cook et al., 2020: Marijuana decriminalization, medical marijuana laws, and fatal traffic crashes in US Cities, 2010-2017	Marijuana decriminalisation Crash rates	Census of fatal traffic crashes from the 2010 to 2017 Fatality Analysis Reporting System	Marijuana decriminalization was associated with a relative increase in fatal crashes involving males and young drivers. Overall Fatal Crash RR, Decriminalisation (1.01: 0.94,1.10) vs Area where Marijuana is controlled (0.91: 0.84,0.98). Male 15-24Yo Decriminalisation 1.13 (1.01, 1.25) vs Area where Marijuana is controlled 0.88 (0.78, 1.00). Male 25-44Yo Decriminalisation 0.97 (0.88, 1.08) vs Area where Marijuana is controlled 0.86 (0.79, 0.94). Page 366	The study found that cities that are located in states that enacted MMLs experienced fewer fatal crashes following medical marijuana legalization. On average, a city experienced 13% more fatal crashes involving 15- to 24-year-old male drivers following city-level marijuana decriminalization (an average of approximately 3.5 more fatal crashes per 100 000 15- to 24year-old males). However, there was no evidence of changes in fatal crashes among females or older drivers, suggesting that young males responded to marijuana decriminalization differently than did other populations. The increase in fatal crashes involving young drivers was most pronounced immediately after decriminalization before attenuating to non-significance in later periods of decriminalization.
Curry et al., 2017: Motor vehicle crash risk among adolescents and young adults with attention-deficit/hyperactivity disorder	ADHD	The New Jersey Department of Transportation's Crash Database	The crash hazard among males with ADHD was 1.42 times higher (95% CI, 1.28-1.56) than among males without ADHD in comparison to females where crash risk was 1.25 times higher (95% CI, 1.08-1.45) for females with ADHD than females without ADHD. Page 760	Adolescents and young adults with ADHD experience an estimated 36% higher motor vehicle crash risk than their counterparts without ADHD.
Davey et al., 2022: Versatile, but not focused, traffic offenders are more likely to be at fault for a fatal crash	Past history of driving offence predictive of fatal crash	crash and traffic history records provided by the Queensland Department of Transport and Main Roads and Coroner's Court	Male drivers who died in fatal collisions were overrepresented among all offence types, representing 81.8% of all offences. For all male related offences, the highest percentages were found for seatbelt offences (94.5%), followed by dangerous driving (94.3%) and driving under the influence of drugs or alcohol (93.5%). Page 145	Most drivers who were killed in a road traffic crash between 2011 and 2019 were male (82.8%) and had received at least one relevant traffic offence in the past five years (76.8%).
Gershon et al., 2018: Crash Risk and Risky Driving Behavior Among Adolescents During Learner and Independent Driving Periods	Crash/Near crash (CNC) Kinematic Risky driving Driving Experience	In car "data acquisition system" telemetries/video recording hardware	During the entire learner period the mean Crash/Near Crash (CNC) rates of novice adolescent and experienced adult drivers were reasonably similar (IRR = 1.67, 95% CI .98 to 2.81). CNC rates of adolescents during the first quarter of independent driving were eight times higher than their rates in the last quarter of the	CNC and Risky Driving rates increased dramatically with the transition from learner to independent driving, on average eight and four times higher, respectively, from the first quarter of

			learner period (IRR = 8.32, 95% CI 2.01 to 34.34). During the independent driving period, CNC rates of the novice adolescent drivers were substantially higher than the rates of the experienced drivers in each quarter (Q1: IRR = 5.43,95% CI 2.85 to 10.36; Q2: IRR = 7.53, 95% CI 3.38 to 16.76; Q3: IRR = 4.27 to 95% CI 1.78, 10.25; and Q4: IRR = 14.15, 95% CI 3.40 to 58.84) and overall (IRR = 6.51, 95% CI 4.03 to 10.51), with no decline over the 12-month study period. CNC rates for both novice adolescents and experienced adult drivers did not differ significantly according to driver gender, time of day, or road surface condition. Risky driving behaviours were higher among male than female adolescent drivers (IRR = 1.73, 95% CI 1.16 to 2.60). For both female and male adolescents, Risky Driving rates were three times higher the first quarter of independent driving compared to the last quarter of the learner period. Page 570	independent driving to the last quarter of the learner period, consistent with previous research. gender differences were also observed, as adolescent males had higher risky driving rates compared to adolescent females.
Hoye et al., 2020: Speeding and impaired driving in fatal crashes—Results from in-depth investigations	Speeding Impairment (Alcohol, drugs, mix of both)	fatal crashes with passenger cars in Norway during 2005 to 2015 that were investigated by crash investigation teams (CITs) of the Norwegian Public Roads Administration.	Fatal crash predictors: Male (Vs female) ORs Excessive speeding vs non speeding (4.499) P<.05 Inappropriate speed vs non speeding (1.799) P<.05 Alcohol vs sober (2.267) P<.05. Page 3	Male and young drivers are overrepresented among speeding drivers (both EXC and INAP). Male drivers are also overrepresented among ACL drivers but not among DRUG and MIX drivers.
Hsieh et al., 2017: Differences between the sexes in motorcycle-related injuries and fatalities at a Taiwanese level I trauma center	Gender Alcohol use Helmet use	Trauma Registry System of a 2400-bed Level I regional trauma center	The significant higher mortality in the patients with a positive BAC than those who had a negative BAC in the male patients (OR = 2.4, 95% CI 1.41 to 2.92; p < 0.001) was not found in the female patients (OR = 2.6, 95% CI 0.62 to 11.20; p = 0.191). Additionally, the significant longer ICU LOS in the patients with a positive BAC than those who had a negative BAC in the male patients (p = 0.009) was not revealed in the female patients (p = 0.411). significant longer hospital Length of Stay (LoS) in the patients without helmet wearing than those with helmet-wearing was found in the male patients (p < 0.001), but not the female patients (p = 0.324). The conditional logistic regression analysis of these well-balanced pairs of patients showed that the gender did not significantly influence mortality (OR 1.11, 95% CI 0.74 to1.68; p = 0.606), implying the higher odds of mortality of the male patients were attributed to population with a risky behaviour that associated with mortality, such as no helmet-wearing and alcohol intoxication, but not the gender per se. Page 116	In this study, after the reduction of the impact of associated helmet wearing status and alcohol intoxication on the mortality assessment between the male and female patients, the logistic regression analysis of these propensity score-matched patients showed that the gender did not significantly influence mortality (OR = 0.82, 95% CI 0.47 to 1.43; p = 0.475), implying the an associated risky behaviours may attribute to the difference of odds of mortality between the male and female patients.

Javid et al., 2022: Analysis of Driver's Socioeconomic Characteristics Relating to Speeding Behavior and Crash Involvement: A Case Study in Lahore	Socio-economic factors	Author designed questionnaire	Single men have a positive association with speeding behaviour. Results showed that drivers who are unmarried men tend to exceed more speed limits by 10 km/h than women. The crash involvement propensity of single drivers and those who are men is more as the coefficient was positive and highly significant. Page 8	Similarly, male drivers' age, vehicle engine size, and type of vehicle they drive were significant predictors of their likelihood to be involved in an collision. The young, single, and male drivers and drivers of cars with an engine capacity above 1.5 L were more likely to speed and be involved in crashes.
Jorgenrud et al., 2018: Association between speeding and use of alcohol and medicinal and illegal drugs and involvement in road traffic crashes among motor vehicle drivers	Previous speeding history Oral fluid sample (drug/alcohol intoxication, medication)	Anonymous author designed survey and fluid samples	In general, men reported more frequent involvement in RTCs and having received speeding tickets in the previous 2 years compared to women, especially those in the youngest age group (16–24 years). A total of 1.4% of the participants tested positive for THC, indicating recent use of cannabis, with a larger proportion of those being men (84.7%). There were also more men among those testing positive for other illicit drugs, mainly stimulants. the use of any illicit drug had a significant, positive association with self-reported speeding tickets (P =.008). However, when subdividing illicit drugs into cannabis and stimulants separately, there was no significant association with self-reported speeding tickets (P=.105 and P=.063, respectively) A larger proportion of those who reported speeding also reported having been involved in an RTC compared to those who did not report speeding (P=.002). In addition, the use of any illicit or medicinal drug was significantly associated with self-reported RTC involvement (P=.004 and P=.009, respectively), with participants testing positive for illicit drugs reporting having been in RTCs more frequently compared to those testing negative for the use of any illicit drugs (17.2 vs. 8.6%). Page 3	Male drivers were more likely to test positive for illegal drugs compared to female drivers. The results also indicate that speeding and the use of various groups of illicit and medicinal drug were associated with self-reported RTCs and that the use of illicit drugs was associated with self-reported speeding. Previous speeding tickets, age, and the use of cannabis were significantly associated with previous RTCs.
Kim et al., 2021: Freeway crashes involving drowsy driving: Crash characteristics and severity in South Korea	Drowsy driving	Police database where drowsy driving was listed as contributing factor in crash	The proportion of male drivers was much higher than that of female drivers in drowsy-driving crashes. Also, the proportions of male drivers in fatal and nonfatal injury crashes were higher than that in no injury crashes. Male drowsy attributed crashes n= 2675 (91.4%) vs Female n= 252 (8.6). Of these, males had a much higher chance of being involved in a fatal collision compared to females with 95.4% of fatal crashes being attributed to men (415). Page 6	In terms of crash frequency, male and middle-aged drivers were mostly likely to be involved in drowsy driving crashes. Relatively speaking the likelihood of a fatal crash increased by 5.3% when a male driver was involved.

Lastrucci et al., 2021: Profiles of risky driving behaviors in adolescent drivers: A cluster analysis of a representative sample from Tuscany region (Italy)	socio-demographic information, social well-being, and mental health, driving behaviours and RTAs, health behaviours), and risk-taking behaviours (risky riding behaviours)	Data provided by the 2018 EDIT surveillance survey. Author developed questionnaire	Compared to females, Males were statistically significantly more likely to engage in the following behaviours: to drive under the influence of alcohol (P>.05), Drive under the influence of drugs (P>.05) and have been involved in a road traffic collision (p>.05). ANOVA analysis whilst not differentiated by gender reported that Alcohol use was implicated in a great chance of crash involvement F (3,2162) =97.4, P<0.001. Likewise, for driving under the influence of Drugs F (3,2162) =77.9, P<0.001). Page 8	Males were more likely to drive under the influence of drugs and alcohol compared to female drivers, and to have been involved in a road traffic collision. Regardless of Gender driving while under the influence of drugs or alcohol increased crash risk significantly.
Li et al., 2016: A rear-end collision risk assessment model based on drivers' collision avoidance process under influences of cell phone use and gender—A driving simulator-based study	Distraction (mobile phone use) Reaction time/crash & crash avoidance	Driving simulator and associated performance recording apparatus	With regard to the behavioural performances in the collision avoidance process, female drivers reacted faster than male drivers when they kept an appropriate car-flowing headway distance. Male drivers reacted slower than female drivers when the initial headway distance was comparatively large. Even in the emergency situation, male drivers still spent longer time in decelerating while reaching a smaller maximum deceleration than female drivers. Male drivers consistently "tail gated" closer to the vehicle in front compared to females, e.g., while using a phone males left a distance of 14.05m compared to 18.31m for female drivers. In the correlation test, the collision or near-collision occurrence had no significant correlation with the different types of cell phone use conditions and the driver's gender, but the use of cell phone or not was found to be a significant factor for the near collision occurrence (r = 0.195, p = 0.026). Page 14	The results indicated that male drivers perceived the risk differently than female drivers, and they tended to take more risks such as reducing safety margin with hazard in front. As for the gender effect, the results indicated that female drivers had longer reaction time than male drivers in critical situation, but they were more quick in braking with larger maximum deceleration rate, and thus kept a larger safety margin with the leading vehicle compared to male drivers.
Mahajan et al., 2021: Sleep-deprived car-following: Indicators of rear-end crash potential	Sleep deprivation (Partial sleep deprivation or PSD)	Sleepiness was measured by using an "Actiwatch 2.0" wearable device Alertness measured using KSS scale Driving simulator was used to run the experimental drives	A repeated-measures ANOVA of KSS rating across three test conditions revealed a significant increase in KSS from baseline, Wilk's lambda = 0.228, F (2,47) = 79.52, p < 0.001, multivariate partial eta squared = 0.77, there was a significant decline in alertness during the PSD test sessions as compared to baseline with no sleep deprivation. The mean time-headway reduced by 0.65 and 1.08 times with Partial Sleep Deprivation (PSD) during Test Session (TS) 1 and TS2, respectively. The professional drivers seemed to adopt 0.25 times lower headways compared to other drivers. As compared to the baseline session, the speed variability increased by 1.34 and 1.28 times during the TS1 and TS2, respectively. The model results show that with unit increase in sleep duration the Speed Variability (SPV) is expected to reduce by 5%. The SPV is expected to be 0.64 times less among the professional cab or taxi drivers and higher due to unsafe driving	This study attempted to explore the effect of PSD on behaviour of drivers during car-following using different safety indicators. These safety indicators were associated with the crash potential index (CPI) derived from the deceleration rate of drivers during car-following task. The study findings showed that PSD resulted in following behaviours: 1) Reduction in time headway, which can increase the crash potential (CPI) values by more than 63 % and 94 % in TS1 and TS2 respectively, as compared to baseline.

			behaviours (violations). It increased by 1.18 times among drivers who sometime engage in over-speeding and 1.55 times among drivers who feel sleepy while driving. Crash potential index (CPI) was modelled using fractional regression using different safety indicators as independent variables. Among the safety indicators, unit increase in critical Time Headway (THW) is likely to reduce the crash potential by 0.52 times. The model showed only slightly significant effect of higher normalized Time Exposure to Critical Gap (TECG) value in increasing the crash potential and the higher speed variability is likely to increase the CPI by 1.45 times. There was no significant effect of driver age, sleep duration, driving duration or annual kms driven by the driver on the model estimates. The model results also showed that unsafe driving practices like driving over the speed limits a few times are likely to double the crash potential index indicating high risk. Page 4	2) Reduction in TECG', shows that drivers were exposed to smaller headways even if it was for a lesser duration during PSD sessions, indicating the tendency of drivers to take cautionary steps to compensate for the risks of PSD, being self-aware of their decline in alertness with PSD. 3) Poor speed control, as indicated by higher SPV during PSD sessions, also contributed to higher CPI.
Mehdizadeh et al., 2019: Driver behaviour and crash involvement among professional taxi and truck drivers: Light passenger cars versus heavy goods vehicles	Risky driving behaviour	Author created questionnaire which included the DBQ	For taxi drivers, older drivers (OR = 0.77, 95% CI 0.66 to 0.91) and higher income level (OR = 0.84, 95% CI 0.79 to 0.98) were negatively associated with involvement in a traffic crash. Results showed that being a single driver (OR = 1.72, 95% CI 1.52 to 2.35), having a higher annual mileage (OR = 1.98, 95% CI %: 1.71 to 2.83), and higher hours of driving (OR = 1.76, 95% CI: (1.45 to 2.64) were associated with an increased risk of crash involvement. More ordinary violations (OR = 1.69, 95% CI 1.49 to 2.38) and more aggressive violations (OR = 1.98, 95% CI 1.76 to 2.95) were also related to an increased risk of traffic crash involvement. Similar results were obtained for truck drivers: Higher number of owned cars (OR = 0.82, 95% CI 0.76 to 0.95) and higher income (OR = 0.86, 95% CI 0.78 to 0.97) were associated with reduced involvement in a traffic crash. More reported errors (OR = 1.21, 95% CI 1.09 to 1.52), more ordinary violations (OR = 1.37, 95% CI 1.17 to 1.63) and more aggressive violations (OR = 1.42, 95% CI 1.23 to 1.76) were related to increased risk of involvement in a traffic crash. Older taxi and truck drivers seem to make more errors than younger drivers in Iran, but older drivers make fewer ordinary and aggressive violations. Regarding the predictors of traffic crash involvement in both samples of taxi and truck drivers, a one unit increase of taxi drivers' age reduced the probability of involvement in traffic crashes by 23%, while this increment had no influence on truck drivers' involvement in traffic crashes	Drivers who transport passengers with light cars were more likely to commit errors, ordinary violations, and aggressive violations than drivers of heavy goods vehicles. Meanwhile, the results showed that truck drivers reported more lapses than taxi drivers. Findings indicated that self-reported risky driving behaviours have stronger influence on the probability of traffic crash involvement among taxi drivers compared to truck drivers in Iranian context. The findings also showed that although taxi drivers commit more risky driving behaviour than truck drivers, both samples have an equivalent (invariant) risky driving factor structure. With regard to risky driving behaviour, an increase in violations (ordinary and aggressive) in two groups of driversincreased the probability of crash involvement almost twice as much for taxi drivers compared to truck drivers.

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Moller et al., 2021a : Socioeconomic status during youth and risk of car crash during adulthood. Findings from the DRIVE cohort study	Socioeconomic status (SES) predictors of crash involvement	Data from a 2003/2004 NSW survey of 20 822 young drivers, the DRIVE study	For all crash outcomes, except for crashes that resulted in hospitalisation or deaths, men of all SES groups had higher rates of crash compared with women. The largest differences between men and women were observed for the highest SES group for single- vehicle crashes and crashes in country areas with 3.7 (95% CI 2.4 to 5.6) and 2.2 (95% CI 1.4 to 3.4) times higher rates in men compared with women, respectively. Men of lowest SES had 2.44 (95% CI 1.77 to 3.36) and 2.23 (95% CI 1.66 to 2.99) times higher rates of crashes in country areas and areas with a speed limit of 80 km/ hour or above, respectively, compared with men of highest SES. There were no differences between men from different SES groups for hospitalised crash or death, crashes in wet conditions, darkness and single- vehicle crashes. Page 759	Drivers who lived in areas of low SES as young adults had a higher risk of car crash during adulthood compared with those who lived in areas of high SES. These differences remained after adjusting for driver demographics and known crash risk factors in the multivariable analysis. Socioeconomic inequalities were more pronounced for crashes that required hospitalisation, crashes in country areas and crashes on streets with a speed limit of 80 km/hour or above. Socioeconomic differences were similar and for some outcomes even larger in women compared with men. Men had higher rates of crash for all groups of SES than women, except for crashes that required hospital admission.
Moller et al., 2021b: Crash involvement among unlicensed 17-year-old drivers before and after licensing at 17 was allowed	Licensed vs Unlicensed driving and crash involvement	Police database	More 17-year-old males than females are involved in crashes and the majority of the involved females are licensed, whereas the majority of males are not. The proportion of persons impaired by alcohol is higher among the unlicensed than the licensed 17-year-olds, but the difference is not significant. Regarding impairment by drugs, the proportion is significantly higher among unlicensed 17-year-olds. Significantly more unlicensed than licensed 17year-olds are speeding at the time of the crash. Male gender (4.06 (1.43–11.60)) and impairment (4.13(1.49–11.46)) significantly increase the odds that the crash-involved 17year-old is unlicensed. Finally, the odds of unlicensed crash involvement are higher for single vehicle crashes (2.42 (1.04–5.64)). One analysis cluster consisting of exclusively males reported that All crashes occurred in an urban area, in a dense environment (91 %), on a dry road with good weather conditions. A large proportion of the crashes occurred on weekends (51 %) or at night (87 %). A large proportion of the 17-year-olds were impaired by alcohol (56 %) or engaged in speeding (33 %). A majority of the crashes was single-vehicle crashes (72 %) and occurred on a straight road (73 %). The open-ended text descriptions indicate that the crashes involved performance errors, such as losing control of the vehicle, hitting an object, or hitting a parked car. A	Regarding unlicensed crash involvement, our results support previous results showing that young males are more likely to be involved in an unlicensed crash than young females. The study also reports that unlicensed crash involvement is associated with other risk-taking behaviours in addition to the unlicensed driving itself, particularly impairment at the time of the crash.

			small share of the crashes occurred in relation to the car being pursued by the police, races, or other car-games. The second male only cluster reported that: all the crashes occurred in an urban area. None of the 17-years-olds were impaired by alcohol, but more than half of them were impaired by medicine or drugs (56 %). The crashes mostly occurred on a straight road (75 %), or in a parking lot (15 %). The majority of the crashes occurred on a weekday (68 %) in evening and night hours (68 %). All most all the crashes involved another vehicle (86 %) where (51 %) a parked vehicle was. The open ended-text descriptions indicate that the majority of the crashes involved stolen cars or cars being pursued by the police. The remaining crashes involved wrong way driving, manoeuvring errors on a parking lot or failure to notice a vehicle in front of the car. Page 4	
Oviedo-Trespalacios et al., 2018: The sex disparity in risky driving: A survey of Colombian young drivers	Self-reported risky driving behaviour	Behaviour of Young Novice Drivers Scale (BYNDS-Sp)	A total of 216 crashes were reported (57% by males) by the participants. In the total sample by sex, approximately 38% (n = 85) of males were involved in road traffic crashes in contrast to 28% (n = 47) of females. No statistically differences by sex were found in the proportion of drivers who self-reported at least one crash (Fisher's exact test, p = 0.052). Male participants also reported being involved in more total road crashes (total crashes = 142, range 1 to 5, M = 1.71, mode = 1.0, median = 1.0) than female participants (total crashes = 74, range 1 to 5, M = 1.61 mode = 1.0, median = 1.0). being male (β = 8.76; p = 0.002) and a longer duration of licensure (β = 2.030; p = 0.001) were associated with greater self-reported risky behaviour in young drivers (p < 0.001). Male drivers who self-reported on average recurrent involvement in transient rule violations had higher odds of being involved in a collision. When the transient rule violation increased by one unit, with time driving with licence remaining constant, the odds of self-reporting a crash are approximately 48% higher (OR = 1.48, 95% CI = 1.01–2.17). For every additional year of having a valid licence, young male drivers had 1.23 times the odds of reporting a collision (OR = 1.23, 95% CI = 1.07–1.39). Young male drivers consistently reported greater engagement in risky driving behaviours, and transient rule violations including speeding in particular. In the current study, 65% of participants mentioned speeding 10–20 km/h over the speed limit at least occasionally and 62%. Young male drivers consistently reported a	The findings in this study suggest that young male drivers engage more frequently in risky driving behaviours compared to young female drivers.

			higher frequency of speeding (68%-84%) compared to females (55%-59%). Page 10	
Ozer et al., 2014: Daytime sleepiness and sleep habits as risk factors of traffic accidents in a group of Turkish public transport drivers	Daytime sleepiness Sleep habits	Epworth sleepiness scale	Forty-nine (15.3%) of the 320 public drivers reported that they had at least one sleepiness related motor vehicle collision and/or near miss collision. Group 1 (collision group) reported less sleep time per night than Group 2 (p<0.001) 6.86(1.0) hrs a night vs 7.39hrs (1.03) P <.001. Logistic regression analysis of risk factors including age, body mass index, daily sleep time, driven distance per year, daytime sleepiness and, constructs of sleep habits revealed that only daytime sleepiness increase the risk of traffic collisions (OR = 1.32, 95% CI 1.19 to 1.47) P<.001. Page 270	Drivers who reported collisions had a significantly higher ESS scores compared to those who did not report involvement in collisions. Self-reported sleepiness was found to be associated with a high risk for traffic collisions.
Pourabdian et al., 2013: The relationship between trait anxiety and driving behavior with regard to self-reported Iranian accident involving drivers	Trait anxiety Self-reported driving behaviour	DBQ Spielberger State-Trait Anxiety Inventory	Independent t-tests showed that mean scores for two subscale of violation (ordinary and aggressive) is higher and mean score of errors subscale in men was significantly higher than women, but other subscale of DBQ mean scores between two genders was not significant. Pearson correlation revealed that between subscale of DBQ and TA scores had a significant positive relation with all the DBQ subscales, and this point is notable that errors and lapses had higher relation with TA than violation subscale. Furthermore, Pearson correlation shows that age had a significant negative relation with three subscales of DBQ (lapses, aggression, and ordinary violation). Page 1117	Men who were involved in a crash were more likely to have reported errors as a factor in the crash compared to women. Trait anxiety was strongly associated with all subscales of DBQ (lapses, aggression, error, and ordinary violation).
Qin et al., 2019: Understanding driver distractions in fatal crashes: An exploratory empirical analysis	Driver distraction	Police crash report database	Younger male drivers had a larger probability of engaging in external distractions than internal car distractions compared to older male drivers. Males were most likely to be distracted by on road distractions, inner cognitive distractions and unknown distractions compared to in vehicle distractions. Page 6	Inner cognitive distractions accounted for the greatest proportion of driving distraction with younger drivers far more likely to be distracted while driving compared to older drivers regardless of gender.
Romano et al., 2021: Alcohol- and speeding-related fatal crashes among novice drivers aged 18-20 not fully licensed at the time of the crash	Alcohol use Speeding	2010–2017 Fatality Analysis Reporting System (FARS) Census data	Compared to females, male drivers were more likely to be alcohol-positive at the time of the fatal crash (p < .01). Males aged 18–20 were more likely to have been speeding at the time of the crash than their female counterparts (p < .01). Latino males were particularly likely to be in a speed-related fatal crash (p < .05).	Compared to female drivers, males were more likely to be; not fully licensed drivers, be positive for alcohol, or speeding at the time of a fatal crash.

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Sadeghi-Bazargani et al., 2015: Adult attention-deficit hyperactivity disorder, risky behaviors, and motorcycle injuries: A case-control study	Self-reported risky driving behaviour Self-reported ADHD tendencies	Motorcycle Riding Behavior Questionnaire Conner's Adult ADHD Rating Scales (the self-report short version)	Riding a motorcycle with an engine size smaller than 100 cc was associated with a lower likelihood of motorcycle traffic injuries (P<0.05). Those who rode a motorcycle only for fun purposes rather than for other reasons were more likely to be injured (P<0.05). Cases were significantly more likely to be married than single (P<0.05). One hundred three (34.5%) of cases versus 35 (24.4%) of controls stated that they have never used helmets while riding a motorcycle (P,0.05). ADHD subscale B (Hyperactivity/impulsivity) (OR = 1.13 95% CI 1.04 to 1.23 *p*=0.003). MRBQ Risky behaviour (OR = 1.22 95% CI 1.01 to 1.45 *p*=0.031). Riding for fun rather than commute (OR = 1.85 95% CI 0.98 to 3.46 P=0.054). Page 2052	Riding behavioural scale, ADHD subscale B scores along with educational level, and reason for motorcycle riding were identified as potential determinants of motorcycle injuries.
Stanojevic et al., 2020: Impact of riders' lifestyle on their risky behavior and road traffic accident risk	"Lifestyle dimensions" Risky behaviour (driving)	The Lifestyle Questionnaire The Risk Behaviour Scale	Lifestyle variables such as Motorcycle as a hobby, Aggressiveness, Motorcycle addiction, and Alcohol and drugs were positively correlated with Rule violations and speeding. Similar relations we found with second factor of risky behaviour, i.e., Self-assertiveness, which was significantly positively correlated with Aggressiveness, Motorcycle addiction and Alcohol/drugs. There were positive correlations between aggressiveness, motorcycle addiction and use of alcohol with traffic collisions. "Culture" was negatively correlated with Tas. Traffic collisions were correlated with Age (-.18 P<.05). Annual mileage (.14 P<.05), Aggression (.34 P<.01), Culture (-.18 P<.05), Motorcycle addiction (.30 P<.01), Alcohol and drugs (.30 P<.01), Rule violations (.29 P<.01) & Self-assertiveness (.28 P<0.1). Page 34	Results show that there is a significant connection between lifestyle and risky behaviour of the riders and traffic collisions. Namely, lifestyle predicts 49% of the variance of Rule violations and Speeding, 40% of the variance of Self-assertiveness and 24% of variance of Traffic collisions of motorcyclist. Considering lifestyle variables, motorcycle addiction showed to be the most significant predictor of the riders` risky behaviour and is also an important predictor of the traffic collisions. Motorcycle addiction is a lifestyle variable that suggests that a person uses the motorcycle not as a means of transportation, but for other motives, such as relaxing, sensation seeking and standing out.
Starkey et al., 2016: The role of executive function, personality, and attitudes to risks in explaining	Driving history Cognitive and executive function assessments	DBQ	Those with a safer driving history (i.e., no self-reported crashes) (Compared to those who had crashed) had significantly better forward planning ability (Tower test) compared to those who had crashes (no crash: Mdn = 18.00, range: 10–25; crash: Mdn =	Within the adolescent group the high-risk drivers (with a crash history) had poorer forward planning, were more accepting of psychological risk and had

self-reported driving behaviour in adolescent and adult male drivers	Personality and Attitudes to risk Self-reported driving behaviour	Wechsler Abbreviated Scale of Intelligence (WASI) & WAIS II, DKEFS International Personality Item Pool Attitudes to Risk Questionnaire DBQ & Driver Attitudes Questionnaire	15.50, range: 13–19; U = 47.50, p = .006), were less accepting of psychological risk (no crash: Mdn = 12.50, range: 17–22; crash: Mdn = 16.00, range:12–22; U = 79.50, p = .035), had lower levels of extraversion (no crash: Mdn = 32.00, range: 10–46; crash: Mdn = 35.50, range: 30–45; U = 74.50, p = .024) and higher neuroticism (no crash: Mdn = 34.00, range: 27–44; crash: Mdn = 29.00, range: 26–33; U = 48.00, p = .002). Page 130	higher levels of extraversion and lower neuroticism, but their scores on the self-report and laboratory measures of impulsivity/inhibition did not differ from those in the low-risk group. It should be noted however that the group of crash-involved drivers was small which limits the generalizability of these findings. Age alone, was not a significant predictor of risky driving.
Sun et al., 2014: Characteristics of 1226 Alcohol-Positive Drivers Involved in Nonfatal Traffic Crashes in Shanghai, China	Alcohol consumption	Crash data from Department of forensic medicine database Headspace gas chromatography to assess BAC	The percentage of male drivers was much higher than that of female drivers (96.2 vs. 3.8%) and females had a lower mean BAC (1.29 mg/mL vs. 1.42 mg/mL). The proportion of drivers involved in drunk driving was also higher for males; 83.1 percent of all male drivers and 74.4 percent of all e female drivers had a BAC≥0.80 mg/mL. The average age was 38 years old for male drivers (ranging from 16 to 78 years old). The difference in the BAC between male drivers and female drivers was not statistically significant ($\chi 2 = 2.24$, $P > .05$, $P = .25$) Page 534	These findings showed that men in Shanghai were much more likely than women to be involved in either driving after drinking or drunk driving resulting in non-fatal collision.
Tokko et al., 2019: Relapse of drunk driving and association with traffic accidents, alcohol-related problems, and biomarkers of impulsivity	Alcohol use Smoking Socio-economic background Personality (adaptive/maladaptive impulsivity) Platelet MAO activity Genotype factors (DAT1 & NPSRI)	Longitudinal Estonian Psychobiological Study of Traffic Behaviour database Self-reported questionnaires Blood samples Adaptive and Maladaptive Impulsivity Scale (AMIS)	The occurrence of active traffic collisions in the whole sample showed a significantly higher proportion of 9R (DAT1) carriers had been involved in active collisions in 2002–2011 ($\chi 2 = 4.5$, p= 0.033). Simple logistic regression analyses showed that in addition to DAT1, the following variables predicted occurrence of active traffic collisions from 2002 until 2011 independently: age, income, AMIS excitement seeking, AMIS fast decision-making, committing DWI and other traffic violations in 2002–2011. Multiple logistic regression model was found that predicted the occurrence of active traffic collisions: higher income (OR= 2.47; 95% CI 1.43 to 4.24), committing DWI (OR= 1.80; 95% CI 1.08 to 3.00), committing other traffic violations (OR= 1.83; 95% CI 1.14 to 2.93) and being a DAT1 9R-allele carrier (OR= 1.58; 95% CI 1.02 to 2.44). Page 7	Propensity to engage in drunk driving can be predicted by higher alcohol use and more frequent occurrence of alcohol-related problems and aspects of impulsivity. Biological markers of impulsivity can be reliably associated with everyday traffic behaviour.

Vollrath et al., 2019: When does alcohol hurt? A driving simulator study	Alcohol consumption (BAC)	Driving simulator Dräger Alcotest 7510 Breathalyzer	Expt. 1 Alcohol did not substantially increase the number of collisions in the complex scenario at an intersection, but led to a strong increase (75% of all drivers as compared to 33% in the placebo group) in collisions in the easy scenario where a pedestrian suddenly crossed the street. Expt 2 There was no difference between the three groups for the complex scenario (pedestrian at intersection; Fisher exact tests p = 0.722). There was also no effect of alcohol for the seemingly easy scenario (p = 0.396). descriptively there were some more collisions in the easy scenario under alcohol, but this difference was not strong enough to become statistically significant. However, when looking at the different dependent variables with ANOVAs, there was a significant main effect of the condition on the speed in the complex scenario, but not in the easy scenario. When comparing only the alcohol group with the sober control group, the speed in the alcohol group in the easy scenario was even significantly larger (t = 2.0, p = 0.048). When comparing only the alcohol group with the sober control group, the speed in the alcohol group in the easy scenario was even significantly larger (t = 2.0, p = 0.048). Page 95	Overall, there was no difference in the number of collisions between drivers under alcohol and those under placebo or sober in the complex scenario. However, in an extension to experiment 1 there was a significant effect of alcohol condition on speed with drivers in the placebo and alcohol group going substantially slower than drivers in the control condition. This would be in congruence with the compensation hypothesis: In a situation which seems difficult and where intoxicated drivers fear that something dangerous might happen, they compensate for the experienced alcohol effects by going slower. This behaviour is rewarded as most driver were able to avoid the collision. Thus, in these complex situations a direct negative effect of alcohol could not be found. This reduction in speed could not be found in the first experiment, as there was no sober control group.
Yan et al., 2021: Temporal analysis of crash severities involving male and female drivers: A random parameters approach with heterogeneity in means and variances	Alcohol Speeding Age	Highway Safety Information System (HSIS) database	Model estimation results illustrate that insurance indicator plays a critical role in all ten models, with stable positive correlation to the occurrence of minor injury crashes over time. Other significant variables specific to minor injury model include alcohol and young drivers. In all male models, it can be found that young drivers have a significantly negative impact on fatal injury crashes. Page 11	Age, alcohol use and lack of insurance are predictors of collisions regardless of gender. For males, young drivers are at particular risk of crash involvement.
Yang et al., 2013: Effects of Personality on Risky Driving Behavior and Accident Involvement for Chinese Drivers	Personality factors	International Personality Item Pool DBQ Self-reported accident involvement	The results revealed that male participants scored significantly higher in the traits of sensation-seeking and normlessness than females, t (222) =2.157, *p* =.032, and t (222) =3.424, *p* =.001, respectively. Moreover, they reported having more aggressive and ordinary violations, t (222) =2.044, *p* =.042, and t(222)= 3.763, *p* = .000, respectively. Collision involvement was associated with the following variables Anger (.16 *p* <0.5) Altruism (-0.218 *p* <.01) Normlessness (0.219 *p* <0.1), ordinary violations (0.141 *p* <.05).	The present study revealed that personality plays an important role in predicting Chinese drivers' unsafe driving behaviours and collision involvement. Male drivers scored significantly higher on trait normlessness (disrespected driving norms). Normlessness was identified as predicting involvement in collision.

			Normlessness were significant predictors for all accidents and at-fault accidents when considered independently. Moreover, anger and normlessness played an important role in predicting serious accidents. When considering all 4 personality variables simultaneously, all accidents were significantly predicted by altruism, B =–.291, Wald's chi-square = 4.855, *p* = .028, and normlessness, B = .248, Wald's chi-square = 8.530, *p* = .003, indicating that drivers who thought little about others and disrespected the norms were more likely to be involved in accidents. Additionally, at-fault accidents were marginally predicted by trait normlessness, B = .257, Wald's chi-square = 3.447, *p* = .063. Page 569	