Recommendation of Suitable Topics for The Road Safety Trust to Focus on Within the Theme of 'Fitness to Drive':

A Rapid Scoping Review

Report for The Road Safety Trust

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List of Abbreviations

AA	Automobile Association
AD	Alzheimer's Disease
ADHD	Attention Deficit Hyperactivity Disorder
AED	Antiepileptic Drug
AMA	American Medical Association
AMD	Age-related Macular Degeneration
ASSIA	Applied Social Sciences Index and Abstracts
CIHR	Canadian Institutes of Health Research
CINAHL	Cumulative Index to Nursing and Allied Health Literature
CMA	Canadian Medical Association
CMV	Commercial Motor Vehicle
CNS	Central Nervous System
COPD	Chronic Obstructive Pulmonary Disease
CPAP	Continuous Positive Airway Pressure
CVA	Cerebrovascular Accident
CVD	Cerebrovascular Disease
DMV	Department of Motor Vehicles
DfT	Department for Transport (UK)
DOT	Department of Transportation (US)
DUI	Driving under the influence
DVLA	Driver and Vehicle Licensing Agency
ED	Emergency Department
EEG	Electroencephalogram
EMBASE	Excerpta Medica database
EU	European Union
FMCSA	Federal Motor Carrier Safety Administration
FTD	Fitness to drive
GB	Great Britain
IAM	Institute of Advanced Motorists
ISRCTN	International Standard Randomised Controlled Trial Number
ITRD	International Transport Research Documentation
LOC	Loss of Consciousness
MUARC	Monash University Accident Research Centre
MVC	Motor Vehicle Collision
NICE	National Institute for Health and Care Excellence

NHS	National Health Service
NHTSA	National Highway Traffic Safety Administration
NIHR	National Institute for Health Research
OSA	Obstructive Sleep Apnoea
PACTS	Parliamentary Advisory Council for Transport Safety
PD	Parkinson's Disease
PNES	Psychogenic nonepileptic seizures
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
PROSPERO	International Prospective Register of Systematic Reviews
PTSD	Post-Traumatic Stress Disorder
RAC	Royal Automobile Club
RCT	Randomised controlled trial
RIP	Research in Progress
ROSAP	Repository of Open Science Access Portal
RoSPA	Royal Society for the Prevention of Accidents
RR	Research Registry
RSRR	Road Safety Research Reports
RST	The Road Safety Trust
RSWP	Road Safety Working Paper
ScR	Scoping Review
SR	Systematic Review
TBI	Traumatic Brain Injury
TIA	Transient Ischaemic Attack
TRB	Transportation Research Board
TRID	Transport Research International Documentation
TRIS	Transportation Research Information Services
TRL	Transport Research Laboratory
UK	United Kingdom
VA	Visual Acuity
VF	Visual Field

Executive Summary

I Background to the Review

The Road Safety Trust wished to commission a study to provide information which would improve its open invitation to applicants for grant funding. The purpose of the study is to recommend suitable topics for The Road Safety Trust to focus on within the theme of 'Fitness to Drive'.

Fitness to drive is a very broad topic covering many factors, such as type of driver (professional and non-professional drivers); age and experience of driver; various medical conditions; mental health and emotional conditions; physical and mental impairments; visual impairments; fatigue; effects of medication; drug and/or alcohol dependency. Over the past twenty years many studies have been carried out and published on the relationships between these numerous factors and fitness to drive. Within the short timescale and budget of this project it would not be possible to carry out a detailed systematic review of the literature. Instead, a rapid Scoping Review would be carried out to identify the extent of research into these various factors related to fitness to drive in the UK and internationally, to identify research gaps where current knowledge is lacking.

II Aims of the Report

To present an overview of the available international literature on fitness to drive, and the research evidence on fitness to drive in relation to specific medical conditions and other factors that may affect driving safety. The report also identifies research gaps, and gaps between evidence and practice. Recommendations are made for topics related to fitness to drive which have the potential to inform policy and improve road safety and which are suitable for funding under the Trust's theme of fitness to drive.

III Research Objectives

To broadly examine the literature on fitness to drive, identify research gaps and recommend topics related to fitness to drive which have the potential to inform policy and improve road safety.

IV Research Questions

1. What is known about fitness to drive?
2. What research has already been carried out on fitness to drive (FTD)?
3. What is the extent of the research literature by FTD topic/condition?
4. Where are the research gaps?
5. What are the road safety implications (e.g. crash risk) for each topic/condition?
6. Which FTD topic/conditions have most potential for

   a) interventions to improve road safety and

   b) influencing policy on road safety?

V Methods and Literature Searches

This scoping review was carried out according to good practice in relation to conducting scoping and systematic reviews outlined by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. All searches were carried out between January and February 2022. Articles published before 2000 and not in the English language were excluded. Due to the enormity of the published research base, in this scoping review data would only be extracted from published systematic reviews. Systematic reviews examine the published literature on a specific topic for data quality and methodological rigor and summarise the available evidence.

1. Data sources

Searches were carried out using electronic databases and manual searches of grey literature (not commercially published literature). We searched the websites of relevant organisations in research active English-speaking countries for reports and other publications which would not have been identified by the database searches. Additionally, international research registries were searched to identify ongoing research in the field of fitness to drive. We contacted Professor Judith Charlton, Director of Monash University Accident Research Centre, Australia as this group has recently completed a comprehensive review of the evidence on the influence of chronic illness on driver crash involvement. Professor Charlton very kindly agreed to share with us a pre-publication copy of their report.

2. Literature searches

There were two stages to the searches:

Search 1 was carried out to broadly scope the literature on FTD. Searches of key databases (ASSIA, CINHAL, EMBASE, PsycINFO, Medline, Scopus, TRID, and Cochrane) were carried out using simple search terms of ‘fitness to drive’, ‘fitness-to-drive’, or ‘driving fitness’. Research registers were also searched using the same terms to identify research in progress, planned research, and recently completed research on FTD.

Search 2 explored the literature on driving for thirteen different groups of medical conditions and topics related to FTD using five databases (CINHAL, EMBASE, PsycINFO, Medline and TRID) to reduce the number of duplicated references. Due to the broad nature of the study brief, we included all medical conditions that have been reported as potentially affecting FTD. Driver age was included to capture differences between older and younger drivers. We also included driving associated with alcohol and drugs (including prescription medicines). The main groups of medical condition and other categories included in the review are shown in **Table 1**.

VI Results

1. Database search results

For Search 1 on fitness to drive the electronic searches returned a total of 1785 published studies (after duplicates had been removed). For Search 2, which was a series of searches on thirteen conditions/topics, the databases returned a total of 22,905 published studies (after duplicates were removed). The PRISMA flow diagram showing the records identified, screened, included, and excluded is in **Appendix I**. **Appendix II** shows the search terms used in Search 2. **Table 1** shows the number of records found for Search 1 (fitness to drive) and Search 2 (specific topics/conditions); the number of systematic reviews identified before screening for eligibility; and the number identified for data extraction. Not all data from the systematic reviews identified by Search 1 were extracted as most were the same as those found later in Search 2. A total of 223 systematic reviews were included in this review.

2. Grey literature search results

Grey literature was acquired via a wide range of sources. Four research registries of proposed and ongoing research were searched and these identified 184 studies on aspects of FTD. Websites of governmental organisations in the UK, Australia, Canada and the USA were searched to identify reports on FTD and funded research on FTD as described below. Website of charitable and non-governmental organisations were also searched for published reports on FTD. In total 176 reports and documents were retrieved for data extraction from the grey literature. After screening for eligibility, 121 'grey' reports were included in this review (PRISMA flow diagram, **Appendix I**).

2.1. UK Department for Transport

The UK Department for Transport (DfT) has archived most of its road safety research reports prior to 2014, and here we found 47 relevant reports on FTD. These reports were a result of DfT commissioned research on the road safety themes of Medical Aspects of Fitness to Drive (15 reports) and Impairment (32 reports). The Impairment theme includes reports on alcohol, drugs (illicit or medicinal), fatigue, sleepiness and fitness to drive, older drivers and vision.

More recently, the DfT has funded nine research projects on the theme of older road users. In 2020 the DfT published three research reports on older people and transport: 'Perceptions and experiences of driver assistance features amongst older drivers'; 'Changing working patterns of older people and implications for transport'; and 'Impact of health and disability on travel behaviour of older people'. Also in 2020, DfT funded a further six projects under the theme of older road users. Five of these projects are now completed and most have produced a final report.

Table 1 Articles found by database searches for Search 1: fitness to drive and Search 2: conditions/topics and driving

Condition/topic	total excluding duplicates	Systematic Reviews identified before screening	Systematic Reviews for data extraction
Fitness to drive (Search 1)	1785	125	21 (Cochrane)
Search 2 total (including all conditions)	22905	360	223
Alcohol	4995	93	25
Cardiovascular	1236	43	13
Diabetes	438	14	2
Drug misuse	696	34	6
Prescription drugs	80	12	8
Hearing	232	6	0
Mental and psychiatric disorders	1553	65	10
Musculoskeletal	341	20	3
Respiratory (inc. COPD)	1414	33	0
Sleep and fatigue	2156	74	26
Vision	4996	66	8
Neurological**	9085	152	57
ADHD	*31*	*16*	*2*
Brain injury	*1972*	*22*	*7*
Dementia/Alzheimer's disease	*624*	*32*	*26*
Epilepsy or Seizure	*459*	*13*	*7*
Multiple Sclerosis (MS)	*28*	*2*	*2*
Parkinson's Disease	*239*	*11*	*4*
Stroke	*698*	*24*	*9*
Driver age*	9926	168	61
Older drivers	*3148*	*73*	*41*
Younger drivers	*3162*	*55*	*20*

* Driver age was subdivided into two groups: older drivers and young/teen/novice drivers.
** Neurological conditions were further subdivided into dementias and cognitive impairment, brain injury, seizures, ADHD, Parkinson's disease, stroke.

2.2. Australia, Canada, USA

In Australia, Austroads produces guidelines for medical licensing, similar to those produced by the DVLA. They also fund research and publish reports which are available on their website. In addition to the above guideline document, we found eight publications relevant to fitness to drive: four publications on older drivers, three on drink driving, one on drug driving.

In Canada, the Canadian Institutes of Health Research (CIHR) has funded 15 research on fitness to drive since 2000. Some projects span more than one topic, these topics are as follows: seven involve older drivers, six focus on Alzheimer's disease, dementia or mild cognitive impairment; two study TBI and driving; and one project is on multiple medications and older drivers. Two projects are extensions of the long running prospective Candrive project on older drivers.

The United States Department of Transportation (DOT) has many reports freely available on its website, most of these are in relation to either older drivers, young drivers, drowsy drivers, and alcohol and drugs and driving.

2.3 UK Charitable and non-governmental organisations

We identified 11 UK charitable or non-governmental organisations concerned with driving and FTD. Several of these organisations both promote and fund research carried out on the topic of FTD as well as publishing reports on their respective websites. The most common topics were older drivers; young or novice drivers; drink driving; drugs and driving; eyesight and driving. Thirty-seven reports and documents were selected for inclusion in this review.

VII Summary of research gaps by condition or topic

We reviewed the evidence from both the published literature (223 systematic reviews) and grey literature (121 reports) in relation to the following medical conditions and topics.

1 Alcohol use disorders

Alcohol ingestion and intoxication is associated with a high proportion of motor vehicle collisions (MVCs), and we found a significant number of articles on alcohol related driving. The literature search identified 4995 papers on alcohol and driving, of which 93 were systematic reviews. After screening, 25 reviews met the inclusion criteria for data extraction. All of the systematic reviews focussed on alcohol misuse, with only the Monash report presenting findings on alcohol use disorders (AUD) and crash risk.

This review of current evidence has identified the following areas which require further research:

- Research linking medically diagnosed AUD with MVC risk, and follow-up audited studies of those detected as driving with impairment with alcohol.
- Drinking and driving has not yet received much research attention in the context of automated driving.
- Research to determine the effects of alcohol on cognitive functioning, using consistent, reliable and comparable measures as well as a measure of cognitive deficits on real-life driving.

- Research to address the paucity of robust evidence on the effect of alcohol on executive functions and driving the morning after heavy alcohol consumption.

2 Cardiovascular conditions

The DVLA guide for medical professionals provides driving rules for a long list of cardiovascular disorders. These disorders do not appear to be a major area of concern for medical licensing. For several conditions the driving restrictions are short-lived and somewhat complicated. For example, Group 1 drivers with angina must not drive when symptoms occur: at rest, with emotion, or at the wheel, but need not notify DVLA and driving may resume after satisfactory symptom control. The literature search identified 1236 papers on cardiovascular conditions and driving, of these 43 were systematic reviews. After screening, 13 papers met the inclusion criteria for data extraction but 12 were principally concerned with other conditions areas, leaving one specifically relating to cardiovascular disease and driving. None of the reviews identified useful areas for future research.

3 Diabetes

In the UK, in 2021, there were approximately 4 million adults with diabetes, with a prevalence of 6.3% (IDF Diabetes Atlas 10th Edition, 2021). Prevalence of diabetes increases with age, so due to our aging population figures are expected to increase significantly. Several complications associated with diabetes can negatively affect FTD. These include cardiovascular disease, peripheral neuropathy, and visual complications. A major concern for drivers with diabetes on insulin is hypoglycaemia which can cause confusion, slowed reaction times and potential loss of consciousness. The literature search identified 438 papers on diabetes and driving, of these 16 were systematic reviews. Most overlapped with other areas and/or were not relevant. After screening, two reviews met the inclusion criteria for data extraction. Additional reports were found in the grey literature.

The Monash review of diabetes and MVC risk included six studies. Of these, three reported a small increase in MVC risk when drivers with uncomplicated diabetes are compared to drivers without diabetes, and three studies reported no difference in MVC risk. Drivers with diabetes who are unable to recognise an imminent hypoglycaemic episode are at particular risk of a MVC. In the grey literature the report of the Older Driver Task Force (2021) identified pedal confusion (mistaking the accelerator for the brake), which is associated with diabetic peripheral neuropathy, as a topic requiring further attention.

There are clear research gaps in the area of diabetes and driving. This review of current evidence has identified the following areas which require further research:

- Research should be carried out on the best ways of identifying drivers susceptible to experiencing hypoglycaemia. Research should include the development of education programmes for drivers of Group 1 and Group 2 vehicles diagnosed with diabetes to help them to identify and react to the signs of an impending hypoglycaemic attack.
- Future research should investigate the relationship between diabetes and crash risk for commercial drivers using well controlled studies which include patients with both type 1 and type 2 diabetes.
- Future research should focus on diabetic peripheral neuropathy and driving as this may contribute to pedal confusion (mistaking the accelerator for the brake) which can lead to MVCs.

4 Driver age

4.1 Older drivers

In 2021, in Great Britain, drivers aged 65 and over accounted for 22% of all licence holders (just under 9 million) and this figure, in line with an ageing population, is increasing every year by around 250,000 (DfT, 2022). The literature search identified 3148 papers on older, or aged drivers. Of these 73 were systematic reviews. After screening, 41 reviews met the inclusion criteria for data extraction. Many reviews overlapped with other conditions (medications, vision, dementia, cognitive impairment, and diabetes). Several reviews examined driving cessation, or examined assessment measures for FTD. Additionally, there were many studies published in the grey literature, many of these were from the UK.

This review of current evidence has identified the following areas which require further research:

- Future research should be carried out into antidepressant use among older drivers. Antidepressants have been associated with increased crash risk in younger populations but have not yet been studied in older drivers.
- Future research is needed to identify and clarify links between falls and crash risk and to develop effective interventions to ensure driving safety in older adults with a history of falls. Falls in older adults appear to be a risk marker for subsequent MVCs and MVC-related injury, but to date the evidence is based on observational studies which are subject to confounding or bias.
- The development of online self-assessment tools for older drivers as these have the potential to provide drivers with tailored feedback to drivers of different abilities and needs.
- The long running prospective Candrive project on older drivers in Canada (funded by CIHR) and the Ozcandrive project in Australia and New Zealand are excellent examples of research into older drivers put to practical use and changing policy. Similar research in the UK would be extremely beneficial, however both of these programmes are costly and government funded. Research topics covered by these projects include:
- Naturalistic studies of driving in those over 70 years.
- Measurement of the impact of medical and functional conditions on crash rates.
- Development of clinical tools that identify older persons who are, and are not, at risk of future crashes and those who need to undergo further in-depth testing of driving ability.
- Development and evaluation of the effectiveness of driver retraining and education programmes.
- Investigate and identify the role of on-road and driving simulator testing within older driver assessments.
- Research on the transition between driving to driving cessation and identify the best ways of achieving a safe transition.

4.2 Younger drivers

In 2021, in Great Britain, there were just under three million drivers aged 25 and under, accounting for 7% of all licence holders (DfT, 2022). Motor vehicle crashes are also a leading cause of death for adolescents and young adults. The literature search identified 3162 papers on young, teen or novice drivers, of these 55 were systematic reviews. After screening, 20 reviews met the inclusion criteria for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed using controlled studies to determine the effectiveness of young and novice driver training using driving simulators. A review of the current evidence found that results were inconsistent across studies, often due to poor methodological quality.
- Research is needed to develop effective prevention strategies to deter mobile phone use during driving, and also to evaluate the effectiveness of any current and future prevention strategies to deter texting and driving among individuals most at risk of engaging in these behaviours.
- Studies of distracted driving have primarily focused on cognitive load and auditory and visual distractors. There is a lack of research designed to understand underlying brain mechanisms that might otherwise facilitate greater understanding of individual variability of normative and risky driving behaviour within the young driving population.

5 Drugs and driving

5.1 Drug misuse

The DVLA (2021) identify a range of categories of drugs related to misuse or dependence. In most cases drivers with drug misuse or dependence must not drive and must notify DVLA if they have persistent misuse or dependence. The literature search identified 696 papers on drug misuse and driving, of these 34 were systematic reviews. After screening, six papers met the inclusion criteria for data extraction. Three of the articles covered both alcohol and drug misuse.

This review of current evidence has identified the following areas which require further research:

- Research is needed to examine the use and effects of psychoactive drugs among drivers, including commercial drivers. There is evidence that some commercial drivers choose stimulant substances to increase productivity, but the extent of this usage and the effect on driving performance and road safety is currently unknown.
- Research is needed on the effects of cannabis use on driving performance and crash risk. The research that has been carried out in this area is often methodologically flawed or of small sample size.

5.2 Prescription medicines/drugs

Driving under the influence of prescription and over-the-counter medication is a growing public health concern. Over one billion prescription items are dispensed each year in England alone. The literature search identified 80 papers on prescription drugs/medications and driving, of these 12 were systematic reviews, some of which overlapped with other related condition areas (alcohol, drug misuse, mental conditions and epilepsy/epilepsy drugs withdrawal). Data were extracted from eight systematic reviews.

This review of current evidence has identified the following areas which require further research:

- Research is needed to examine how combinations of medications may affect fitness to drive, and what advice is given to patients regarding the effects of medications on driving.
- Research is needed using a well controlled study to examine the relationship between medication use, driving impairment and crash risk. The few studies that have been carried out have shown small to moderate increases in crash risk, but most of these studies had methodological limitations.

- Research is needed, using a well-designed study, to establish the relationship between prescribed psychoactive drugs (including benzodiazepines) and crash risk. Additionally, associations should be explored between specific medications and the risk of driving impairment or MVC. Existing studies have shown increases in crash risk, particularly for younger drivers, however different studies present conflicting results due to methodological limitations.
- Research is needed to determine which antidepressant treatments have least impact on driving performance. There is some evidence that newer antidepressants have a reduced impact on driving skills, but more evidence is needed.

6 Hearing

The DVLA allows Group 1 drivers to drive with profound deafness without the need to inform DVLA. (DVLA, 2021). Group 2 drivers with deafness must be assessed but may not need to inform DVLA if they are able to communicate in an emergency through other means. The literature search identified 232 papers on hearing loss and driving, of these six were systematic reviews. After screening no papers met the inclusion criteria for data extraction.

The Monash review authors concluded that hearing loss has no effect on MVC risk and there is no scientific evidence to support the inclusion of hearing loss in medical standards for fitness to drive.

7 Mental and psychiatric disorders

Mental and psychiatric disorders encompass a wide range of conditions which may affect FTD including anxiety, depression, schizophrenia, behavioural and personality disorders. Previous reviews suggest that drivers with mental or psychiatric disorders are at a higher risk of crash causation and other adverse driving outcomes than the general population. The literature search identified 1553 papers on psychiatric or mental disorders and driving, of these were 13 systematic reviews. After screening, 10 reviews met the inclusion criteria for data extraction. There was overlap with the categories of prescription drugs and young driver.

This review of current evidence has identified the following areas which require further research:

- Research is needed to investigate risky driving behaviours in the presence of personality disorders.
- Research is needed to identify the characteristics of people with psychiatric disorder most at risk of MVC. Such research should include objective assessments of psychiatric disorder and MVC risk and include a measurement of driving exposure. Research should also identify driving risk among those with psychiatric disorder and consider the impacts of long-term psychiatric disorders and their pharmacological treatments on driving performance.
- A consensus-based approach (using a panel of experts) should be considered for reassessing the recommendations of FTD guidelines for psychiatric disorders.

8 Musculoskeletal disorders

Musculoskeletal conditions include rheumatoid arthritis, osteoarthritis, osteoporosis, and bone fractures. The DVLA guide for medical professionals does not cover these conditions. However, these often debilitating conditions can affect a person’s mobility and function and

ability to safely drive a motor vehicle. The literature search identified 341 papers on musculoskeletal disorders and driving, of these 20 were systematic reviews. After screening, three papers met the inclusion criteria for data extraction. Two reviews focussed on arthritis or rheumatoid arthritis and another on total knee or hip arthroplasty. No reviews have yet assessed crash risk.

This review of current evidence has identified the following areas which require further research:

- Research is needed to determine the best strategies to promote safety and driving comfort for those living with arthritis.
- Research is needed to assess driving performance and related safety outcomes for drivers with rheumatoid arthritis, as the available evidence suggests that driving difficulties and inadequate modifications are common among those with rheumatoid arthritis.
- Research is needed using a large sample size to examine self-perceived readiness to drive, objective data, and specific details on surgical and clinical management after total knee arthroplasty or total hip arthroplasty. Future studies should consider pain levels, especially since narcotic use for pain management while driving can affect FTD and examine the influence of pain on driving to determine adequate pain management and return to driving.

9 Neurological disorders

9.1 Attention Deficit Hyperactivity Disorder (ADHD)

Patients with ADHD are more prone to physical injuries, including motor vehicle accidents, fractures and brain injuries. Prevalence figures for the UK are difficult to ascertain as many cases are undiagnosed. The global prevalence of ADHD is estimated as between 2% and 7%. The literature search identified 31 papers on ADHD and driving, of these 16 were systematic reviews. After screening, two papers met the inclusion criteria for data extraction, one overlapped with the literature on young drivers, the other overlapped with medicinal drug use.

This review of current evidence has identified the following area which requires further research:

- ADHD medication treatment has a protective effect on mood disorders, suicidality, criminality, substance use disorders, accidents and injuries, traumatic brain injuries, motor vehicle crashes, and educational outcomes. However, the research evidence suggests that future work is needed to develop innovative methods to improve adherence to ADHD medications. Most previous studies of pharmacological treatments for ADHD examined stimulants and none of the reviewed studies reported findings on non-stimulants alone.

9.2 Brain injury

There are several types of brain injury (e.g. aneurisms, brain tumours, concussion, encephalitis, and traumatic brain injury (TBI)). In the UK, NICE has estimated that 1.4 million people annually attend accident and emergency departments with a head or brain injury (NICE, 2014). TBI is associated with a wide range of impairments which may impair driving fitness. These include cognitive impairments, fatigue, visuospatial perception, insight, judgement, attention, comprehension, reaction time, memory, sensation, muscle power, coordination, and vision. Functional and cognitive sequelae after TBI can continue for years post injury. The literature

search identified 1972 papers on brain injury and driving, of these 22 were systematic reviews. After screening, seven reviews met the inclusion criteria for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed to determine a consistent and standardised approach to assessing FTD following mild TBI.
- Research is needed on post-acute driving assessment and driving rehabilitation after TBI.
- Research is needed using well designed studies to establish the risk of MVC or driving impairment after TBI. Studies should control for TBI severity and time post-injury and use objective measures of fitness to drive and MVC risk.

9.3 Dementia and Alzheimer's Disease

In the UK it has been estimated that there were over 850,000 people with dementia in 2019, with a predicted rise to one million by 2025 (Alzheimer's Society, 2022). True figures are likely to be higher due to sub-optimal rates of diagnosis. Prior to a diagnosis of dementia, many people will be living with some form of cognitive impairment which can also negatively affect driving. The literature search identified 624 papers on dementia or Alzheimer's disease and driving, of these 32 were systematic reviews. After screening, 26 papers met the inclusion criteria for data extraction. Several reviews examined cognitive and/or on-road tests for assessing FTD among patients with dementia or mild cognitive impairment. Others examined interventions to assist older drivers with dementia. Other reviews covered the topic of driving cessation. A consistent message from the evidence is that there is a need for tools with sufficient validity to help clinicians assess driving ability among patients with dementia, particularly in the early stages.

This review of current evidence has identified the following areas which require further research:

- Research is needed on MVC risk and dementia as there is a currently a lack of evidence on crash risk. However, current evidence shows that even mild stages of dementia are associated with a substantially higher risk of failing an on-road driving assessment.
- Research is needed to investigate the driving performance and associated neural networks of subgroups of Alzheimer's disease (very mild, mild, moderate) and mild cognitive impairment (MCI).
- Research is needed using high quality studies to examine the benefits of driver assessment for people with dementia and identify those assessments which a) facilitate continued driving; b) reduce accidents; and c) identify those unfit to drive.
- Further work is needed to evaluate the responsiveness of driving assessment measures to known changes in health conditions, and to develop methods to distinguish driving lapses and errors due to dementia from those due to other causes.
- Research is needed to develop a reliable, valid composite battery of cognitive assessments that can correctly determine FTD in individuals with dementia.

9.4 Epilepsy and/or seizures

According to Epilepsy Research UK (2022) there are over 600,000 people in the UK with a known diagnosis of epilepsy, equating to one in 103 people. Epilepsy can be caused by a brain injury, brain tumour, or stroke. Epilepsy may also be a result of a neurodegenerative disease such as dementia. The literature search identified 459 papers on seizures or epilepsy and

driving, of these 13 were systematic reviews. After screening, seven papers met the inclusion criteria for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed to determine the MVC risk associated with seizures or epilepsy. Large, controlled population-based studies are needed using objective measures of crash risk rather than self-reporting of MVCs by drivers themselves. The current available evidence on MVC risk associated with seizures or epilepsy is mixed and not of high quality. More accurate risk estimates are needed to inform licensing decisions and fitness to drive guidelines.
- Research is needed to better understand the impact of epilepsy, and epilepsy surgery, on driving and road safety, especially where driving continues in violation of restrictions.
- Research is needed to determine the risk of accidents in drivers with psychogenic nonepileptic seizures (PNES) as there is currently no firm evidence base for PNES-related driving regulations.

9.5 Multiple Sclerosis (MS)

Multiple sclerosis (MS) is a chronic condition which affects the central nervous system. MS can affect vision, balance and cognitive processes. The MS Society estimates that there are over 130,000 people with MS in the UK, with nearly 7,000 people newly diagnosed annually (MS Society, 2022). The literature search identified 28 papers on MS and driving, of these two were systematic reviews for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed of high methodological quality with large prospective samples of adults with and without MS in order to compare predictors of FTD.
- Research is needed to develop screening tests with proven validity for identifying high-risk drivers with MS so that physicians can provide guidance to their patients.

9.6 Parkinson’s disease

Parkinson’s disease (PD) is a chronic, progressive neurodegenerative condition resulting from the loss of the dopamine-containing cells of the substantia nigra (NICE, 2022). PD is most common in elderly people, with a prevalence of 1–2% in people older than 65 years of age. A Parkinson's UK report found that in 2015 there were approximately 137,000 people in the UK living with PD, however they warned this may be an underestimate due to PD being underdiagnosed in older age-groups (Parkinson's UK, 2018). The literature search identified 239 papers on Parkinson’s disease and driving, of these 11 were systematic reviews. After screening, four papers met the inclusion criteria for data extraction.

This review of current evidence found no specific recommendations for further research on PD and fitness to drive, but PD should be included in future studies of other dementias.

9.7 Stroke, Cardiovascular Accident (CVA) or Transient Ischemic Attack (TIA)

According to the Stroke Association (2022) the annual incidence of strokes in the UK is about 100,000, and there are 1.3 million stroke survivors in the UK. The literature search identified

698 papers on stroke, CVA or TIA and driving, of these 24 were systematic reviews. After screening, nine papers met the inclusion criteria for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed to quantify MVC risk after stroke and to identify robust clinical predictors of crash risk.
- Research is needed on FTD among commercial drivers after stroke. A review of the current evidence found that no studies provided direct evidence that neurological assessments can predict crash risk among commercial drivers, and limited evidence that some neuropsychological tests can identify on-road driving performance after stroke.

10 Respiratory disorders including COPD

The DVLA guidance for medical practitioners refers to disorders of respiratory function including asthma and COPD. The literature search identified 1414 papers on respiratory disorders including COPD and driving, of these 33 were systematic reviews. After screening, nine reviews met the inclusion criteria for data extraction. However, all of these reviews were about sleep apnoea and there was complete overlap with reviews extracted under Sleep disorders below. From the perspective of FTD it appears that respiratory disorders should be included within the broader topic of sleep disorders.

11 Sleep and fatigue

Sleep disorders include Obstructive Sleep Apnoea (OSA), excessive daytime sleepiness, narcolepsy, insomnia, and drowsiness. The DVLA states that drivers with excessive sleepiness with or without OSA must not drive (DVLA, 2021). It has been estimated that there are 1.5 million adults in the UK with OSA but up to 85% are undiagnosed and consequently remain untreated (British Lung Foundation, 2015). The literature search identified 2156 papers on sleep disorders and driving, of these 78 were systematic reviews. After screening, 26 papers met the inclusion criteria for data extraction.

This review of current evidence has identified the following areas which require further research:

- Research is needed to examine the relationships between the severity of sleep apnoea and daytime sleepiness and crash risk.
- Research is needed to determine whether other potential risk factors (e.g., body mass index, comorbid conditions, use of sedating medications) have an impact on crash risk in drivers with sleep apnoea.
- Research should examine whether subjective sleepiness predicts physiological drowsiness while driving using highly controlled high fidelity or naturalistic/track studies.
- Research should include objective measures of sleep disorders and MVC risk; measurement of driving exposure; medication use/compliance; comorbidities and disorder severity. In order to do this a population-based controlled study should be carried out across multiple sites.
- Research should focus on sleep disorders and crash risk among commercial (Group 2) drivers due to the limited available evidence.

12 Vision

Good vision is fundamental to safe driving. The prevalence of visual impairment is estimated to be about 596 million worldwide (Burton et al., 2021). Cataracts, age-related macular degeneration (AMD), glaucoma and diabetic retinopathy are the leading causes of visual impairment, particularly in older adults (Flaxman et al., 2017). All of these conditions can negatively affect FTD. The literature search identified 4996 papers related to vision and driving, of these 76 were systematic reviews. After screening, eight papers met the inclusion criteria for data extraction.

The essential components of visual function for driving are acuity, static acuity, dynamic acuity, visual fields, visual attention, depth perception, and contrast sensitivity (Desapriya, et al (2014). Current vision screening regulations and cut-off values required to pass a licensing test vary considerably between countries. In the UK, when taking the driving test, only visual acuity is used to assess that the visual standards for driving are met. A Cochrane review of vision screening of older drivers found no controlled trials which assess the effects of vision screening tests on subsequent MVC reduction.

This review of current evidence has identified the following areas which require further research:

- The development of valid and reliable visual screening tests that can predict fitness to drive.
- Well-designed studies are needed on visual impairment and MVC risk and on-road driving performance. These should have a large sample size involving drivers with a range of visual loss and impairment.
- Research is needed on FTD with common eye conditions such as cataract, glaucoma, AMD and diabetic retinopathy, as well as studies on the binocular visual fields necessary for safe driving.

13 Multiple medical conditions

Most medical guidelines on FTD are condition specific, with few considering how a combination of medical conditions, and potentially multiple medications, may affect FTD. However, many drivers are likely to have more than one condition that may affect their FTD, and this is especially the case among older drivers. We did not search specifically for papers on multiple conditions, but this topic became apparent as an important issue as we examined individual conditions.

This review of current evidence has identified the following area which requires further research:

- There is limited research evidence on multiple medical conditions and MVC risk and we recommend future research on this topic, ideally a large scale prospective population-based controlled study.

14 Professional drivers

Professional drivers was not a specific topic, but our search terms included professional drivers to ensure that papers on commercial and professional drivers were captured. Given the high mileage covered by professional and commercial drivers, it is important to consider medical conditions that are most likely to affect them. The literature review identified a number of conditions which have been linked with crash risk for drivers of Group 2 vehicles. These include sleep (particularly OSA), fatigue, diabetes, and drug use.

This review of current evidence has identified the following area which requires further research:

- Research is needed using a large well-designed study to investigate the role of fatigue, sleep and sleep disorders in commercial drivers and crash risk. The study should include empirical measures of risk factors and outcomes. Studies to date have been mostly of small sample size and with methodological flaws.

15 The role of health professionals

The role of health professionals was not included in specific search terms, and no systematic reviews were found on this topic. However, from the evidence presented under individual medical conditions, it became clear that health professionals have a vital role in advising patients on their FTD. There were several reports in the grey literature which made recommendations for future research.

This review of current evidence has identified the following areas which require further research:

- Research is needed to determine the current knowledge of medical and other health professionals on issues of FTD and identify barriers to giving that advice.
- Research should explore the best ways of delivering education and training on FTD to doctors and other health professionals. Training should include the detection of driving issues; consideration of multiple conditions; the effects of medications and combinations of medications on driving performance; and the best ways to discuss driving and offer advice to patients.

VIII Conclusions

This scoping review has examined the current literature on FTD, both broadly and more specifically. We reviewed systematic reviews and research reports for 18 medical conditions which can affect fitness to drive, and for the topics of older drivers, younger drivers, professional drivers, and health professionals.

We have identified the medical conditions and topics affecting FTD and summarised the findings of previous research in each area. A great deal of research spending and effort has created a wealth of information on FTD. However, there are many areas where the evidence is either inconclusive, due to poor study design, or where no research has been carried out. We have identified research gaps by highlighting the areas needing future research under each condition and topic listed above. Clearly there is much work still to be done, and the RST needs to focus its funding call on research areas which have the highest potential to improve road safety in the UK. With this in mind we have selected 10 topic areas which are most likely to achieve the Trust's charitable purpose.

IX Recommendations

After a careful review of the available evidence and identification of research gaps, the following topics are recommended as areas for the RST to focus on in its forthcoming funding call on FTD. Research in these areas will address research gaps and has the potential to influence policy and improve road safety.

Older drivers

Older drivers have been the focus of considerable previous research, however there are several areas where more research is needed. Most older drivers are safe and competent drivers but increasing age and declining health can lead to driving difficulties. Although there is evidence that many older drivers regulate their driving to compensate for difficult driving conditions, they may need advice, support and assessment to enable them to continue driving safely for longer. This review has identified a need for the development of self-assessment tools for drivers to assess their FTD.

Older drivers are more likely than younger drivers to have multiple medical conditions and be prescribed multiple medications. Research is needed to examine this more fully and explore the advice provided by health professionals on fitness to drive for those with multiple conditions.

Brain Injury

Brain and head injuries are common and are associated with many persistent functional and cognitive impairments which can impair fitness to drive. This review has identified a need for research to determine a consistent and standardised approach to assessing FTD following TBI, particularly mild TBI.

Dementia (all types)

Due to the progressive nature of this degenerative disease which affects multiple cognitive impairments, there will come a point when sufferers are unfit to drive. Because many patients continue to drive for some time after the onset of their illness, and because lack of insight is a consequence of the disease, it is vitally important that health professionals assess the driving safety of their patients and offer driving advice appropriately in a timely manner.

The evidence reviewed suggests that FTD is severely impaired in moderate and severe dementia, irrespective of the type of dementia, including Parkinson's disease. Furthermore, mild cognitive impairment, which is often a stage before a formal diagnosis of dementia, is associated with driving risk. There remains a need for effective screening tests to identify patients in the early stages of dementia who are unfit to drive. It is therefore recommended that all forms of dementia and FTD is a topic which should be considered for funding by the RST.

Diabetes

Diabetes is a common condition with approximately 4 million adults with diabetes in the UK. There are clear research gaps in the area of diabetes and driving. A major concern for drivers with diabetes is the risk of a hypoglycaemic episode which can cause confusion and potential loss of consciousness. Complications of diabetes can affect fitness to drive, such as visual complications and peripheral neuropathy.

Suggested research topics are the relationship between diabetes and crash risk for commercial drivers; the best ways of identifying drivers susceptible to experiencing hypoglycaemia; and diabetic peripheral neuropathy and driving as this may contribute to pedal confusion.

Prescription drugs

Each year over one billion prescription items are dispensed from pharmacies in England alone. Medicines that can seriously impair driving (antidepressants, opioids, gabapentinoids, benzodiazepines, and sleeping tablets) were prescribed for 16.8 million people in England in a single year (2017/18). This review of the literature has identified the importance of the topic of prescription medications/drugs and over the counter medications to FTD. The systematic reviews we examined identified several areas where new research is needed. In particular we recommend that research should examine how combinations of medications may affect FTD, and what advice is given to patients regarding the effects of medications on driving. Research should also be carried out to examine the relationship between medication use, driving impairment and crash risk.

Sleep and fatigue

Sleep disorders are common. A review of the available evidence suggests that there is an increased MVC risk associated with sleep disorders (including OSA, narcolepsy and insomnia). In particular, OSA is a common condition, with an estimated 1.5 million adults in the UK living with OSA, yet up to 85% are undiagnosed and may be putting themselves and other road users at risk. OSA is more prevalent among older adults, men and those that are overweight. There is some evidence that commercial drivers and HGV drivers are at particular risk of OSA due to an unhealthy diet and lack of exercise (i.e. long hours spent sitting down driving). OSA brings a risk of excessive sleepiness, with an elevated risk during hours of darkness. Work and shift patterns of commercial and HGV drivers often mean they spend considerable time driving during darkness.

This scoping review of the evidence suggests that further research should be carried out on sleep disorders and FTD using a population-based controlled study which includes measures of comorbidities and medication use. Due to a lack of current evidence, research should also be carried out on sleep disorders and crash risk among Group 2 drivers. It is therefore recommended that sleep disorders and FTD is a topic which should be considered for funding by the RST.

Vision

Both the current review and the Monash review recommend that visual impairment and FTD should be the focus of future research. Many previous studies have noted that the visual standards for driver licencing vary considerably around the world. The UK has one of the most lenient visual standards, in that after passing the driving test a driver can continue to drive until the age of 70 without any formal checks on their vision. When the driver must renew their licence at age 70 there is no requirement for an eyesight test, which is the case in many other countries. In the UK several authors have commented on this and have recommended mandatory eyesight tests at regular intervals, however there is no clear evidence that visual impairment is a major cause of motor vehicle accidents. It is recommended that research is carried out to assess the MVC risk attributable to impaired vision.

Professional and commercial drivers

Fitness to drive among professional and commercial drivers has received little research attention. However, the nature of their work places these drivers at risk. Time pressures can cause anxiety, the sedentary nature of the work (sitting for long hours) and often poor diet can increase the risk of obesity, diabetes, cardiac disorders, fatigue and sleep disorders. Commercial drivers are at increased risk for OSA as described above. Although DVLA driving standards are more strict for Group 2 drivers, drivers of vans and small delivery vehicles are likely to be driving with a Group 1 licence with more lenient medical standards. This review has found significant research gaps in the literature regarding commercial drivers and therefore recommend that this is a topic which should be considered for funding by RST.

Health professionals

The role of health professionals on advising their patients on FTD is fundamental to medical licensing. Patients are often unaware of how their medical condition, or combination of medical conditions and medications may affect their FTD. They rely on health professionals to advise them, but this does not always happen. There is evidence from earlier studies that health professionals often do not feel sufficiently knowledgeable about the medical rules for driving. It is recommended that the current state of knowledge on FTD among doctors is assessed, and education and training packages on giving patients advice on FTD are developed. It is also important to develop training for doctors in considering the cumulative effect of multiple medical conditions in combination with multiple medications, and how these may impact on FTD.

Research in this area has the potential to improve doctor's knowledge of medical aspects of FTD and ensure that patients who should not drive receive appropriate advice, assessment and support. It also has the potential to improve the reporting of medical conditions to the DVLA and thus improve road safety.

A full systematic review

This scoping review has unearthed a wealth of research on the topic of FTD in general and in relation to specific medical conditions. In this scoping review we were able to examine the evidence summarised in published systematic reviews and in the grey literature. However, there are hundreds of studies which will not have been included in systematic reviews. We therefore recommend that a full systematic review be carried out for the topics recommended for funding under this call by the RST.

1 Introduction

1.1 The study brief and time constraints

The Trust wished to commission a study to provide information which would improve its open invitation to apply for grant funding. The purpose of the study is to recommend suitable topics for the Road Safety Trust to focus on within the theme of 'Fitness to Drive'. Suitable topics are those where there is either a gap in the evidence or a gap between evidence and practice in the UK. The topics selected should be those where there is some evidence that they are likely to garner interest and support. The principal aim of the study is to help the Road Safety Trust identify within this broad subject which particular areas to focus on in its call for proposals.

The Trust required a study to be carried out and a report submitted within 5 or 6 weeks so that deadlines related to the forthcoming funding call on the theme of fitness to drive could be met.

1.2 The aim of the report

This report aims to present both an overview of the international literature on FTD, and the research evidence on FTD in relation to specific medical conditions and other factors that may affect driving safety. The report also aims to identify research gaps, and gaps between evidence and practice. Recommendations are made for topics related to FTD which have the potential to inform policy and improve road safety and which are suitable for funding under the Trust's theme of FTD.

1.3 Background to this scoping review

Prior to undertaking this review, an initial search of the literature suggested that there is a substantial body of literature in the field of FTD. FTD is a very broad topic. Research in this area covers numerous factors, such as type of driver (professional and non- professional drivers); age and experience of driver; various medical conditions; mental health and emotional conditions; physical and mental impairments; visual impairments; fatigue; effects of medication; drug and or alcohol dependency. Within the short timescale and budget of this project it would not be possible to carry out a detailed systematic review of the literature and research quality assessment for each of these factors in relation to FTD. Instead, the literature would be searched more broadly to identify the extent of research into these various factors related to FTD in the UK and internationally. A rapid Scoping Review would be carried out following guidelines recommended by PRISMA-ScR (Preferred Reporting Items for Systematic reviews and Meta-Analyses extension for Scoping Reviews).

1.4 FTD and guidelines

Driving is a complex and demanding task involving a range of physical, cognitive and sensory processes. The visual and auditory senses gather information about the road environment, and this information is processed using cognitive skills including memory and judgement to make decisions about the driving task. These decisions are acted upon by the musculoskeletal system in order to physically operate the vehicle. The assessment of FTD is dependent upon consideration of these requirements of the driving task. Various medical conditions can affect a driver's ability to drive safely. However, it is not necessarily the medical conditions themselves that affect driving performance, rather it is the functional or cognitive impairments that may be

associated with them. Also important is the extent to which individual drivers are able to adapt or compensate for impairments.

Many countries publish guidelines on medical aspects of FTD. These guidelines are usually aimed at medical professionals, with some providing information for allied health professionals. Examples include Australia's Austroads: 'Assessing fitness to drive' which was last updated in 2017 (Austroads, 2017); the Canadian Medical Association: 'The Driver's Guide: Determining Medical Fitness to Operate Motor Vehicles' last updated 2019; and the US National Highway Traffic Safety Administration (NHTSA): 'Driver fitness and medical guidelines' (NHTSA, 2009). However, the quality of FTD guidelines has been found to be inconsistent across different countries (Rapoport, 2015).

In Europe, the 2006 EU Driving Licence Directive sets out 'Minimum Standards of Physical and Mental Fitness for Driving a Power-Driven Vehicle' but it is left to individual member states to set their own standards. However, these European standards are 16 years old and due for revision in 2022. There are more recent Europe-wide recommendations for visual impairment (Visual standards for driving in Europe, 2017). A topic group on FTD has recently published recommended standards for the evaluation of medical FTD in Europe (Englund, et al, 2020). A recent report by the European Transport Safety Council has concluded that the current EU approach to assessing whether drivers are medically fit to hold a licence requires substantial revision (Carson, et al, 2021).

The most up-to-date guidelines are in the UK. The Driver and Vehicle Licensing Agency (DVLA) produces guidelines for medical professionals which are updated approximately every six months: 'Assessing fitness to drive: a guide for medical professionals' (DVLA, 2021). These guidelines cover the full range of medical conditions which may affect the safe control of a vehicle and are intended to assist doctors and other healthcare professionals in advising their patients on FTD. The medical rules for driving with medical conditions are more stringent for drivers with Group 2 licences (e.g. HGV, bus) than for drivers with Group 1 licences (e.g. car, van, motorcycle). For example, after a first unprovoked seizure Group 1 drivers must cease driving for 6 months whereas Group 2 drivers must cease driving for 5 years (DVLA, 2021).

In 2021 the number of driving licence holders in Great Britain (GB) (full and provisional) was 41,075,262 which represents 76.7% of the GB population of driving age (Driving and Vehicle licensing Agency (DVLA), 2022; Office for National Statistics (ONS), 2022). In the UK, it is both the responsibility and legal duty of the driving licence holder to notify DVLA of any injury or illness that would have a likely impact on safe driving ability, with the exception of some short-term conditions that are unlikely to continue beyond three months (DVLA, 2021). As most licence holders do not know if their medical condition may impact their FTD, or for how long, doctors and other health professionals such as optometrists should advise their patients accordingly using these guidelines. However, research suggests that health professionals do not always offer appropriate advice (e.g. Hawley, 2010) or may give inaccurate or inconsistent advice (e.g. Mansur, et al, 2018; Townsend et al, 2014).

2 Research Objectives and Research Questions

2.1 RST review objective

To broadly examine the literature on FTD, identify research gaps and recommend topics related to FTD which have the potential to inform policy and improve road safety.

2.2 RST review questions

1. What is known about FTD?
2. What research has already been carried out on FTD? (what is the extent of the literature?)
3. What is the extent of the research literature by FTD topic/condition?
4. Where are the research gaps?
5. What are the road safety implications (e.g. crash risk) for each topic/condition?
6. Which FTD topic/conditions have most potential for

   a) interventions to improve road safety and

   b) influencing policy on road safety?

3 Methodology

This scoping review was carried out according to good practice in relation to conducting scoping and systematic reviews outlined by PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. Due to the very restricted timescale for the review (5-6 weeks), it was necessary to refine the methodology to accelerate the review process. Given the enormity of the body of literature on FTD it would be impossible to for two researchers to extract data from all relevant journal articles and reports. Therefore, we decided to extract data only from systematic reviews.

4. The Review Process

4.1 Literature search

The goal of the literature search was to be as exhaustive as possible within the scope of the review. To this end we searched both published international literature using electronic databases and grey literature (not commercially published literature). We also manually searched the websites of relevant organisations in research active English speaking countries for reports and other publications which would not have been identified by the database searches. Additionally international research registries were searched to identify ongoing research in the field of FTD. Key researchers active in the field of driving research were contacted to ensure that we included the most up-to-date literature and evidence.

4.2. Inclusion and exclusion criteria

Due to the broad nature of the study brief, we included all medical conditions that have been reported as potentially affecting FTD. Additionally, we included all ages of driver in order to capture differences between older and younger drivers. We also included literature on driving associated with alcohol and drugs (including prescription medicines). The main groups of medical condition and other categories included in the review are shown in **Table 1**.

Inclusion criteria:

a) drivers of motor cars, taxis, vans, LGV, HGV, buses, and minibuses. (Group 1 and Group 2 drivers)

b) all ages of driver

c) all medical conditions which may affect FTD

d) substances which may affect driving e.g. alcohol, drugs, medicines

Exclusion criteria:

a) literature not published in English language

b) articles published before 2000

c) articles not relevant to FTD

d) articles specifically on pedestrians, scooters, cyclists, or motorcyclists

4.3 Search strategy

Given the broad nature of this review two sets of searches were carried out. The initial search used the broad term of 'fitness to drive'. The second search explored the literature on driving for thirteen different groups of medical conditions and topics related to FTD as described below.

The searches were carried out between January and February 2022.

4.3.1 Search 1: broad search of 'fitness to drive'

Search 1 was carried out to broadly scope the literature on 'fitness to drive'. Searches of key databases (ASSIA, CINHAL, EMBASE, PsycINFO, Medline, Scopus and TRID) were carried out using simple search terms of 'fitness to drive', 'fitness-to-drive', or 'driving fitness', searching in keywords and/or abstract. Additionally, the Cochrane Library of Systematic Reviews was searched using the same search terms. Research registers were also searched using the same terms to identify research in progress, planned research, and recently completed research on FTD.

4.3.2 Search 2: condition/topic specific searches

The search terms for Search 2 were identified using the results of Search 1. The broad searches enabled us to identify the medical conditions and other categories (such as driver age; alcohol and drugs; type of driver such as professional or private) that may affect FTD.

As a result of these initial searches, some highly relevant key studies were identified which also helped to devise relevant search terms. Next, more specific search terms were created, tested and refined for each condition or topic related to FTD. This testing and refining ensured that the search terms were capturing as many relevant articles as possible.

The actual search terms are reproduced in **Appendix II**, these include the search strategies for each condition and topic of interest for each of the main databases used. For Search 2, the number of databases searched was reduced to five (CINHAL, EMBASE, PsycINFO, Medline and TRID) to reduce the number of duplicated references. The search terms were used to search anywhere within the document to capture as many references as possible.

4.4 Sources of data

4.4.1 Electronic databases

Electronic databases were used to search the published literature. The databases used covered the disciplines of medicine and allied health professionals; psychology; public health; and transport safety (ASSIA via ProQuest; Medline, PsycINFO, and EMBASE via Ovid; CINAHL via EBSCO; Scopus via Elsevier; and the TRID: TRIS and ITRD database). Also searched was the Cochrane Library of Systematic Reviews.

4.4.2 Grey literature and other sources

Grey literature was searched using research registries (ISRCTN Registry, and Research Registry), study protocols (PROSPERO), and various websites.

Grey literature is often not peer reviewed and the quality of the evidence presented is variable. Grey literature searches are also time consuming and due to the short timescale of the current project we were only able to search a limited number of sources. **Table 2** shows the grey literature sources used in this review and the number of relevant papers found.

Websites of the following groups of organisations were searched (**Table 3** provides a detailed list):

- Governments (UK, EU, US, Canada and Australia): for details of funded projects on FTD; government reports on FTD; guidelines; and policy documents.
- Monash University website: for road safety publications and reports.
- Transport Research Laboratory (TRL): for publications/reports on FTD.
- Charitable organisations involved in road safety: for published reports, fact sheets, policy documents.
- Professional organisations: for published reports, fact sheets, policy documents.

Table 2 Grey Literature and Other Sources Searched (January – February 2022)

Websites and Registries Searched	Data type	No. papers on FTD
Registries and Libraries		
ISRCTN Registry	register of all clinical research studies (proposed, ongoing or completed	14
Research Registry	register of research studies	3
NIHR PROSPERO	prospectively registered systematic reviews in health and social care.	21
Cochrane Library	Cochrane Systematic Reviews (21 reviews found on driving, 10 of these on FTD)	10
TRB (Transportation Research Board) Research in Progress (RIP) database	register of projects in progress. Contains abstracts and data on active projects on FTD.	167
Governmental and associated organisations		
Austroads (Australia)	guidelines on FTD, reports, policy documents Good search system with subcategories. 1 guideline on FTD for health professionals. 4 publications on older drivers, 3 on drink driving, 1 on drug driving.	9
Canadian Institutes for Health Research	list of funded studies on FTD	18
College of Optometrists	carries out research on vision and FTD, publications on FTD	3
Department for Transport UK)	commissions research and publishes reports on fitness to drive. But publications are mostly archived, no useful search facility. Reports very difficult to find.	47
Driver and Vehicle Licensing Agency (DVLA)	guidelines on FTD for medical professionals updated 6 monthly	1
European Commission	section on Mobility and Transport – Road Safety. Guidelines, vision standards.	2
Monash University Accident Research Centre (MUARC) Australia	Leading research centre for transport safety. Publish reports and other resources. 12 reports on driving/FTD	12
United States Department of Transportation (DOT)	many reports on FTD but not a numbered list. PDFs are available via the Repository of Open Science Access Portal (ROSAP). Many on older drivers and FTD.	5
Transport Research Laboratory (UK)	publications on FTD. Not easy to search, no refinable search function.	16

Table 3 Searches of Charitable and Non-governmental Organisations

Charitable and non-governmental organisations searches	Summary of data available
AAA Foundation (US)	funds projects on FTD. e.g. sleep and crash risk, and prescription medications and driving. Several research publications on drug driving and distracted driving.
Agilysis (Road Safety Analysis)	research, publications/reports on road safety and driver crash risk. 4 on young/adolescent drivers. 1 on mobile phone use and driving
Brake	have a Knowledge Centre and fact sheets. Do not appear to commission research directly
European Transport Safety Council (ETSC)	publishes reports on transport safety
IAM RoadSmart	commissioned research on driver distraction and mature drivers. Produces policy and research documents including drink-driving and mature drivers
Parliamentary Advisory Council for Transport Safety (PACTS)	produces reports, e.g. drink driving
RAC Foundation	commission research and publish reports on FTD.
Road Safety GB	host the Road Safety Knowledge Centre, linking to research and publications on road safety under various topics including road users and road user behaviour
Road Safety Foundation	publish research on older drivers, younger drivers, safer roads, safer vehicles and crash risk.
Road Safety Observatory	has published research on FTD, e.g. vision and FTD. Accessed via RoSPA website.
Road Safety Trust	Grant funding organisation for projects on road safety
Royal Society for the Prevention of Accidents (RoSPA)	publishes a series of fact sheets on FTD and road safety. Offers resources for health professionals
Safer Roads Foundation	no details of funded projects or reports

4.5 Contacts with key researchers

Contact was made with Professor Judith Charlton, Director of Monash University Accident Research Centre, Monash University, Victoria, Australia. This group has recently completed a comprehensive review of the evidence on the influence of chronic illness on driver crash involvement. Professor Charlton very kindly agreed to share with us a pre-publication copy of her report: *Influence of chronic Illness on crash involvement of motor vehicle drivers: 3rd edition.*

5 Search Results

5.1 Database Search results

Records produced by the searches were imported into Endnote 20.1 software to assist the review process. Separate Endnote libraries were created for the different topic areas. Endnote was also used to find and remove duplicated references.

5.1.1 Search 1: Broad search of fitness to drive

Results of the database searches are shown in **Table 4** below. A total of 4385 references were found, of which 59% (2300) were duplicates, leaving 1785 unique references on FTD. In addition to the electronic database searches, the Cochrane Library of Systematic Reviews was searched using the same search terms, returning an additional 21 Cochrane Reviews on the topic of FTD.

Table 4 Results of FTD search by database (2000-2022)

Database	Full name of database/description	Number of Hits
ASSIA	Applied Social Sciences Index and Abstracts. Includes: health, social services, psychology, sociology, economics, politics, race relations and education	107
CINAHL	Cumulated Index of Nursing and Allied Health Literature. Includes: Journal articles, book chapters, dissertations, pamphlets, selected conference proceedings, standards of professional practice, educational software	555
EMBASE	Includes: all aspects of human medicine and related biomedical research	763
MEDLINE	Medical database Includes: over 5,400 journals in medicine, nursing, dentistry, veterinary medicine, health care systems and preclinical sciences	568
PsycINFO	Abstract database of psychological literature	291
Scopus	Abstract and citation database of peer-reviewed literature: scientific journals, books and conference proceedings. Includes: science, technology, medicine, social sciences, and arts and humanities	1285
TRID	Transport Research International Documentation. Includes: 1.25 million records of transportation research worldwide	816
Total database results		4385
Duplicated references		2600
Total unique FTD references		**1785**

5.1.2 Search 2: condition/topic specific searches

Five electronic databases were searched using the search terms identified for the thirteen medical conditions/topics. There was considerable overlap of references between conditions/topics. The same journal article could be found multiple times if it covered more than one condition/topic and was found by more than one database. For example, a paper on FTD

among older adults with diabetes and visual impairment would be captured by the database searches on three separate topics: a) diabetes, b) driver age, and c) vision. This same paper could also be found by three different databases. Consequently, it was most important to remove duplicated references from the totals. The PRISMA Flow diagram (**Appendix I**) presents the number of references found per database, the number of duplicates and resulting articles selected for data extraction.

The results of the individual searches for the thirteen main medical conditions/topics are shown in **Table 5**. As the searches were carried out using five databases, duplication of references was inevitable. The references were imported into Endnote referencing software and we used the Endnote 'find duplicates' tool to identify duplicates. The software is not perfect, and some duplicates will remain. However, given the timescale of the study, and the large number of references, it was not possible to manually search for further duplicates. Consequently, the figures reported for totals 'excluding duplicates' will be higher than the true figures. **Figures 1 and 2** illustrate the quantity of published research for each medical condition/topic.

Table 5 also shows the number of systematic reviews identified among the references for each condition/topic. As this is a more manageable number, we were able to hand-search these for duplicates and remove any that were found. The resulting total of systematic reviews for data extraction was 774. However, this number was reduced for data extraction purposes as some systematic reviews were duplicated across the different medical conditions/topic, for example a review of dementia among older drivers would appear both in the dementia group and the driver age group.

Table 5 Articles found by database searches for conditions/topics and driving

Condition/topic	total refs found	duplicated references	total excluding duplicates	Systematic Reviews
Alcohol	8836	3840	4995	93
Cardiovascular	2252	1008	1236	43
Diabetes	933	495	438	14
Drug misuse	1754	1058	696	34
Prescription drugs	134	54	80	6
Hearing	409	177	232	6
Musculoskeletal	1518	1177	341	20
Sleep and fatigue	4878	2722	2156	74
Driver age	17022	7096	9926	168
Mental disorders	1930	377	1553	65
Neurological*	13265	6021	9085	152
Respiratory (inc. COPD)	2106	692	1414	33
Vision	7591	2595	4996	66
Total	62628	27312	37148	772

* Neurological conditions were further subdivided into dementias and cognitive impairment, brain injury, seizures, ADHD, Parkinson's disease, stroke.

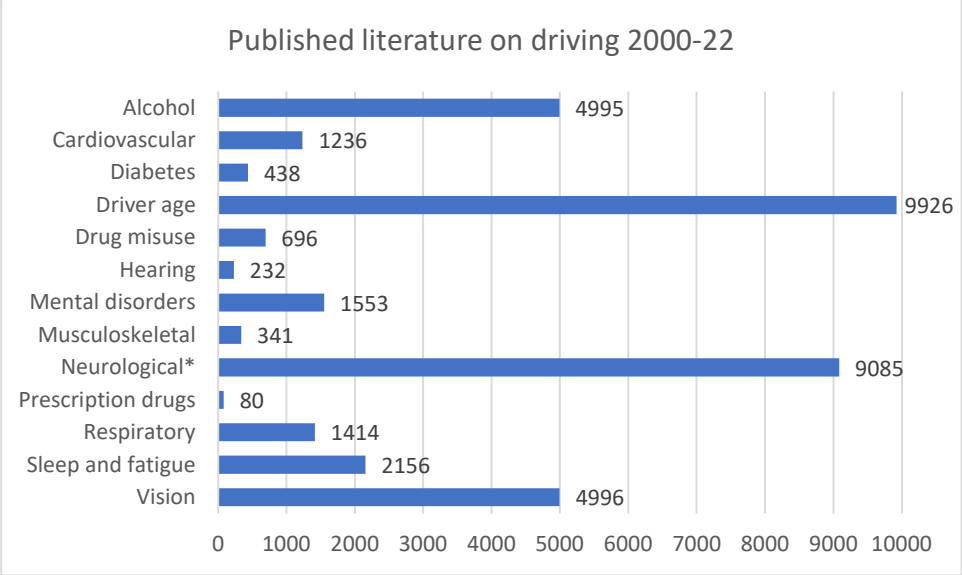

Figure 1 **Total number of hits (duplicates removed) identified by electronic databases for each condition associated with FTD: 2000 – 2022**

* Neurological conditions were further subdivided into dementias and cognitive impairment, brain injury, seizures, ADHD, Parkinson's disease, stroke.

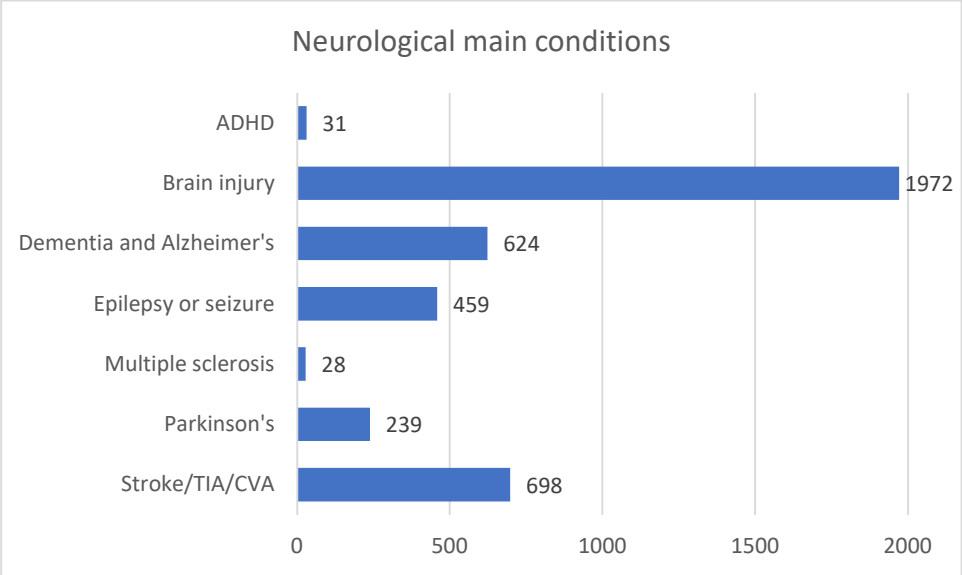

Figure 2 **Total number of hits (duplicates removed) identified by electronic databases for main neurological conditions and FTD: 2000-2022**

5.2 Grey literature and other sources search results

5.2.1 Austroads (Australia)

Austroads produces guidelines for medical licensing, similar to those produced by the DVLA. They also fund research and publish reports which are available on their website for registered users. In addition to the above guideline document, we found eight publications relevant to FTD: 4 publications on older drivers, 3 on drink driving, 1 on drug driving.

Since 2000 Austroads has sponsored the Older Driver Model Assessment Program - a multi-stage project that has aimed to develop, implement and trial a new licensing model for assessing older drivers' fitness to continue driving. We identified three reports for inclusion in this scoping review. Two reports are about older drivers and are summarised in section 8.4.1 below. The other is a report on A National Approach to Measuring Non-fatal Crash Outcomes: (2019). This report describes a pilot project for a national approach to the design, development and implementation of a process to supply routine national data on non-fatal hospitalised road injuries in Australia. It concluded that this pilot project has provided proof of concept for such an approach.

5.2.2 Canadian Institutes for Health Research (CIHR)

A search of the CIHR registers for funded research projects found 15 studies on FTD which have been funded since 2000. Many of these projects have now reported their findings and there are several articles in the published literature arising from these projects. **Appendix IV** contains a list of the 15 research projects. Some projects span more than one topic, these topics are as follows: seven involve older drivers, six focus on Alzheimer's disease, dementia or mild cognitive impairment; two study TBI and driving; and one project is on multiple medications and older drivers. Two projects are extensions of the long running prospective Candrive project on older drivers. Candrive 'Canadian Driving Research Initiative for Vehicular Safety in the Elderly' was initially funded by CIHR in 2002 and continues to this day. The Candrive research team developed a national network of researchers and partners focusing on older driver research with the aim of improving safety and fair assessment for older drivers. It is a national longitudinal study involving 7 sites and 1300 older drivers that generate knowledge for use by transportation policy makers, clinicians and the general public to improve the safety and quality-of-life of older drivers in Canada and abroad. The Candrive research program since progressed to "The CIHR Team in Driving in Older Persons (Candrive II) Research Program" (2008-2013). In 2009 an Australian collaboration (Ozcandrive) joined the project funded by an Australian Research Council (ARC) Linkage Grant. Together the two studies are linked as the OZCandrive Candrive/Ozcandrive prospective study.

The Candrive research aims are: 1) Increase understanding of the natural history of driving in those over 70 years; 2) Measure the impact of medical and functional conditions on crash rates; 3) Develop of clinical tools that identify older persons who are and are not at risk of future crashes and those who need to undergo further in-depth testing of driving ability; 4) Develop and evaluate the effectiveness of driver retraining and education programs; 5) Clarify the role of on-road and driving simulator testing in the process of older driver assessment; 6) Lessen the difficulties associated with the transition to non-driving; and 7) Assist seniors to identify and use automobile technological innovations to their advantage.

5.2.3 Department for Transport (DfT)

In the early 2000s the DfT commissioned research on the theme of Medical Aspects of Fitness to Drive. This theme (Theme 6) is described by DfT as:
'*This is a programme of DfT road safety research that aims to provide better scientific evidence to support the work of the DVLA Medical Unit and to improve the basis on which medical professionals give driving advice to persons suffering from several medical conditions*.' …. '*This programme of research aims to improve the quality of evidence underlying both licensing decisions and medical advice to ensure that risks to road safety are minimised while drivers are not unnecessarily restricted*'.

There was another relevant theme (Theme 3) around the same time which commissioned research on 'Impairment', described by the DfT as:
'*These projects are primarily concerned with drivers who are impaired due to alcohol, drugs (illicit or medicinal) or fatigue, and ways of reducing the problems through enforcement and publicity. Attention is also being given to the influence of alcohol on pedestrian accidents*.'

Between these two themes 47 projects were funded and published by the DfT as Road Safety Research Reports (RSRRs) or Road Safety Working Papers (RSWPs). Fifteen were under the theme of Medical Aspects of Fitness to Drive. Thirty-two were under the theme of Impairment. As well as the factors mentioned in the DfT description above, this theme includes several reports on sleepiness and FTD, older drivers and vision. **Appendix V** gives the titles of commissioned projects for both themes.

Searches of the DfT website and the National Archives had failed to locate these research reports. However with some detective work, the list of DfT research reports was found in a web archive:
(https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/501151/list-of-road-safety-reports.csv/preview

The PDFs of these reports are available via this website. However, the list is not indexed or searchable and it is unfortunate that these reports are difficult to access as a great deal of quality research was carried out for DfT which is now rarely cited.

In 2020 the DfT published three research reports on older people and transport: 'Perceptions and experiences of driver assistance features amongst older drivers'; 'Changing working patterns of older people and implications for transport'; and 'Impact of health and disability on travel behaviour of older people'.

Also in 2020 DfT funded a further six projects under the theme of older road users. Most of these projects are now completed and some have published a final report. The six projects were as follows:

- An update of the Older Driver Task Force report "Supporting Safe Driving into Old Age" (led by the Road Safety Foundation) (Older Driver Task Force, 2021)
- A survey of the views of older drivers on road safety interventions (led by IAM RoadSmart) (Hawley, 2021)
- Visual impairment and road casualties among older road users and the role of optometrists in promoting road safety (led by the College of Optometrists) (report in press)
- Feasibility of powered wheelchair and mobility scooter assessment and training (led by Driving Mobility)
- Older driver mobile simulator screening (led by Agilysis)
- Effect of cognitive impairment on spatial orientation and navigation (led by the University of East Anglia and ongoing)

5.2.4 Transport Research Laboratory (TRL) publications

A search of the TRL publications website found 15 studies on fitness drive published from 2000 onwards. Topics include alcohol and drugs and driving; driver fatigue; driver distraction; novice drivers; older drivers; diabetes and driving; and disability and driving. The studies together with a brief summary are presented in **Appendix VI**.

5.3 Research in progress or recently completed

5.3.1 PROSPERO

A search of the PROSPERO prospective register of systematic reviews found 21 studies on FTD. **Table 6** presents the results. Four of these studies are shown as completed, the remaining 17 are listed as ongoing as of 19th February 2022. Several of these reviews form part of the Monash report.

5.3.2 ISRCTN Registry

The ISRCTN Registry contained records of 14 ongoing or recent studies on FTD. Seven of these studies are in the UK, three from Canada, two from Germany, one from Switzerland and one from the Netherlands. Topics studied are: young or novice driver education (3 studies, 2 UK, 1 Canada); sleep and FTD (2 studies, 1 UK, 1 Canada); drink driving (2 studies, 1 UK, 1 Switzerland); drugs and driving (2 studies, 1 Germany, 1 Netherlands); commercial drivers (1 study, UK); ADHD and FTD (1 study, Canada); FTD after neurological disorders (1 study, Germany); casualty reduction through speed limits (1 study, UK); and a study trialling patient information leaflets on driving regulations and mental health disorders (UK). **Table 7** shows the range of topics covered.

Table 6 PROSPERO Prospective register of systematic reviews on FTD (as at 19/2/22)

Year registered	Authors	Title	Status
2020	Holden et al	Driving and dementia from the perspective of heath and social care professionals - an integrative review	Ongoing
2020	Zaccaro et al	Systematic study of road accidents in the home-work journey occurred due to the use of psychoactive substances and alcohol	Ongoing
2020	Knott et al	A Systematic Review of Driving Simulator, Virtual Reality, and On-Road Interventions for Driving-related Anxiety	Ongoing
2020	Alvarez et al	Young and under the influence: A systematic literature review of the impact of cannabis on the driving performance of youth	Ongoing
2020	Wood et al	Determining the risk of motor vehicle crashes and unsafe on-road performance for drivers with vision disorders.	Ongoing
2019	Rapoport et al	Determining the risk of motor vehicle crashes for drivers with psychiatric disorders	Ongoing
2019	Hara et al	What is the position of the driving simulator in rehabilitation after a stroke? A systematic review	Ongoing
2019	Koppel et al	Determine the risk of motor vehicle crashes for drivers with a sleep disorder(s)	Ongoing
2019	Koppel et al	Determine the risk of motor vehicle crashes for drivers with epilepsy and/or seizures	Ongoing
2019	Tepper et al	The processes and tools of clinical decision-making used by occupational therapists in practice settings to assess fitness to drive: a systematic review	Ongoing
2018	Koppel et al	The safety benefits of older drivers attending an in-person licence renewal: a systematic review	Ongoing
2018	Bellagamba et al	Standardized on-road instruments assessing fitness-to-drive in people with cognitive deficits: a systematic review	Completed
2018	Koppel et al	The effectiveness of mandatory reporting by health professionals of drivers with medical conditions	Ongoing
2018	Stephan et al	Systematic review of the association between antidepressants and traffic crashes	Ongoing
2018	Stephan et al	Systematic review of the effect of antidepressants on driving as measured in a driving simulator or on-road experiment	Ongoing
2017	Koppel et al	Effectiveness of age-based mandatory assessments for reducing motor vehicle crashes among older drivers	Ongoing
2018	Knott et al	Insufficient sleep and fitness to drive in shift workers	Completed

2017	Krasnuik et al	Clinical determinants of fitness to drive in persons with multiple sclerosis: systematic review	Completed
2016	Rashid et al	Cognitive assessment as a predictor of on-road driving ability in people with dementia	Ongoing
2016	Rapoport et al	A collaborative international knowledge synthesis to update guidelines for determining medical fitness to operate motor vehicles with dementia	Completed
2014	Marshall et al	Systematic review of the effectiveness of conditional licensing for medically impaired drivers	Ongoing

5.3.3 Research Registry

The Research Registry (RR) register of new research studies contained records of one study on FTD. This is a retrospective review of current practice in Perth and Kinross (Scotland) to inform clear guidelines around referral to occupational therapy for specialist assessment for people with dementia or mild cognitive impairment who are still driving.

5.3.4 Transportation Research Board (TRB) database

The TRB Research in Progress (RIP) database contained records of 167 ongoing or recent studies on FTD. **Table 7** shows the topics covered. The majority of these projects are currently taking place in the USA. Fifty of the 167 projects are investigating FTD in relation to driver age, 31 on older drivers and 14 on young, teen or novice drivers. Among the studies on older drivers a few examine specific medical conditions such as dementia, for example: '*Does Monitoring Naturalistic Driving through Vehicle Instrumentation Make a Difference in Decision-Making for Fitness to Drive in Early Stage Dementia? An Intervention Study*'.

Eleven studies are about FTD among commercial drivers, for example: two studies on '*Assessing and Improving the Cognitive and Visual Driving Fitness of CDL* [commercial driver's licence] *Drivers*' phases 1 and 2. There are an additional four studies on bus drivers and FTD, for example: '*A Research Framework for Studying Transit Bus Driver Distraction'.* Fourteen studies are specifically investigating crash risk among a range of driver groups, for example: '*Crash Risks by Commercial Motor Vehicle (CMV) Driver Schedules, Phase I*' project.

Distracted driving is being addressed by 12 current studies, and a further five studies are investigating FTD and cell phone use, for example: '*Impact of Education and Awareness Programs on the Usage and Attitude towards Texting while Driving among Young Drivers'.*

Eight studies are investigating drugs and driving, for example: '*Determining the Potential of Drugs to Impair Driving*', and six studies are investigating alcohol and driving.

Six of the 167 current studies are carrying out systematic reviews of the literature on aspects of FTD. Data were extracted from the abstracts for these reviews and included in the scoping review. The topics of these reviews are: state of knowledge on older drivers; state of knowledge on novice drivers; medical conditions and driving; vulnerability of motorcyclists to crashes and injury; drugs and driving state of knowledge; and driving simulators.

Table 7 Research in Progress Registers by Topic Area

Main Topic	TRB no. of studies	Registries (ISRCTN and RR) no. of studies
Age:	50	
Older drivers	31	
Young/teen/novice drivers	14	3
Comparisons of older/younger drivers	5	
ADHA and FTD		1
Aggression	2	
Alcohol/drink driving	6	2
Attitudes	4	
Autism and driving	1	
Autonomous vehicles	3	
Blind persons	1	
Bus drivers	4	
Cell phones/smart phones	5	
Cognition/awareness/attention	4	
Commercial drivers	11	1
Crash risk/analysis	14	
Deaf persons	1	
Decision making	2	
Dementia		1
Distracted driving	12	
Driver alertness	2	
Driver behaviours	11	
Driver education	3	
Driver performance	4	
Driving risk assessment	3	
Drowsy driving	5	
Drugs and driving	8	1
Fatigue	1	
Graduated licensing	2	
Impaired drivers	1	
Interchanges and intersection crashes	2	
Medical conditions and driving	1	
Mental illness and FTD		1
Prescription medications and FTD		1
Sleep and fitness to drive		2
Stroke/neurological conditions and FTD	1	1
Traffic safety	3	1
Total	167	15

5.4 UK Charitable and non-governmental organisations

Table 3 (p.33) lists the charitable and non-governmental organisations concerned with driving and FTD. Several of these organisations both promote and fund research carried out on the topic of FTD as well as publishing reports on their respective websites. All of these websites have been visited and the most relevant publications accessed for this review. It is clear that

there has been a great deal of excellent research carried out in the UK over the past twenty years. It was beyond the scope of this review to evaluate all of this research, but we summarise some of the most pertinent recent research in the sections below.

A considerable amount of research has been conducted on the topic of older drivers. For example, the RAC Foundation has published reports on 'Driving Choices for the Older Motorist: The role of self-assessment tools' Lang et al (2013); 'Can older drivers be nudged? How the public and private sectors can influence older drivers' self-regulation' (Berry, 2011); Maintaining safe mobility for the ageing population (Box et al., 2010); and 'Supporting older driver mobility' (Gandolfi, 2020). IAM RoadSmart has published two reports on older drivers which survey their health, attitudes, behaviour and self-regulation (Hawley, 2015; Hawley, 2021). The Road Safety Foundation has published several research reports on older drivers, most recently the reports of the Older Driver Task Force: 'Supporting safe driving into old age' (2016) and 'Supporting safe driving into old age: Second edition' (2021). They have also published reports on younger drivers, motorcyclists, and pedestrians.

The Road Safety Trust has recently funded a study on the assessment of older drivers which aims to 'gather new knowledge of elderly drivers' risk alongside testing for new approaches supporting improved fitness to drive assessments'. The Fit2Drive project involves a 'telematics clinical trial seeking to understand both older elderly risk behaviours and how new technology could help make FTD processes more cost effective, fairer and safer for all'.

Younger drivers have been the topic of research for several organisations such as Agilysis who have published four reports on young/adolescent drivers. They have also published research on mobile phone use and driving. The RAC Foundation have published several research reports on young and novice drivers, including studies on crash risk, accident types, and graduated licensing.

Vision and driving has been a topic of research covered by various UK organisations. The College of Optometrists have carried out, funded and published research on vision and FTD, for example the recent DfT funded project on visual impairment and older road users.

The Road Safety Observatory published a useful review of eyesight and driving, carried out in 2012/13 and updated in 2017. The archived Road Safety Observatory can be accessed via the Royal Society for the Prevention of Accidents (RoSPA) website.

RoSPA have produced several fact sheets on FTD which are useful for both drivers and health professionals. For example, fact sheets on older drivers, eyesight and driving, drink driving, drugs and driving, driver fatigue.

The Parliamentary Advisory Council for Transport Safety (PACTS) has published several reports on drink driving and drug driving. IAM RoadSmart have also published research on drink driving.

5.5 Monash report on chronic Illness and crash involvement

This report presents individual systematic reviews on 11 medical conditions: alcohol use disorders; diabetes; epilepsy/seizure disorders; hearing loss; psychiatric disorders; sleep disorders; vision disorders; dementia; stroke/TIA; syncope; and traumatic brain injury. Plus a systematic review on multiple medical conditions and crash risk.

6. Data extraction and Interpretation of results

A data extraction form was designed using best practice guidelines for scoping reviews. As this review concentrated on systematic reviews, the form included an assessment of data quality adapted from the BMJ Best Practice framework for assessing systematic reviews (BMJ Best Practice, 2022). The data extraction form was designed to collect information pertinent to the specific research questions of this scoping review. The extraction form was then piloted and further refined. A copy is reproduced in **Appendix III**. Two reviewers extracted data from the systematic reviews identified by the data searches for each of the 18 medical conditions and other topics.

6.1 Systematic reviews

6.1.1 Search 1: 'fitness to drive'

Search 1 identified 1785 articles where 'fitness to drive' was mentioned in the title or abstract. Of these, 125 were identified by Endnote software as systematic reviews. Data were extracted from the 21 Cochrane reviews identified by the search. Data were not extracted from the remaining SRs as most were also identified by Search 2 below within specific topic areas. Data extraction efforts were concentrated on Search 2 due to the short project timescale.

6.1.2 Search 2: condition/topic specific searches

Search 2 identified a total of 22,905 articles using the detailed search terms for each condition or topic. Of these, Endnote software identified 360 systematic reviews. **Table 1** shows the number of systematic reviews found for each condition or topic of interest pre- and post-screening. At the screening stage, irrelevant papers and those which did not provide any useful information on FTD were discarded. This left 223 systematic reviews for full data extraction. **Figure 3** shows the number of included reviews by topic/condition.

6.2. Monash report on chronic Illness and crash involvement

The Monash report is the result of a large multi-centred study by an international project team with funding from multiple organisations and it represents a major research effort. The report comprises of a collection of individually reported systematic reviews of the evidence of motor vehicle crash risk for 11 different medical conditions. Our data extraction form was not used for this report, instead we identified key findings from the report for each medical condition and added these to the findings from the other systematic reviews. The Monash report presents a number of recommendations for policy and practice, together with recommendations for future research. These recommendations have been incorporated into our own recommendations.

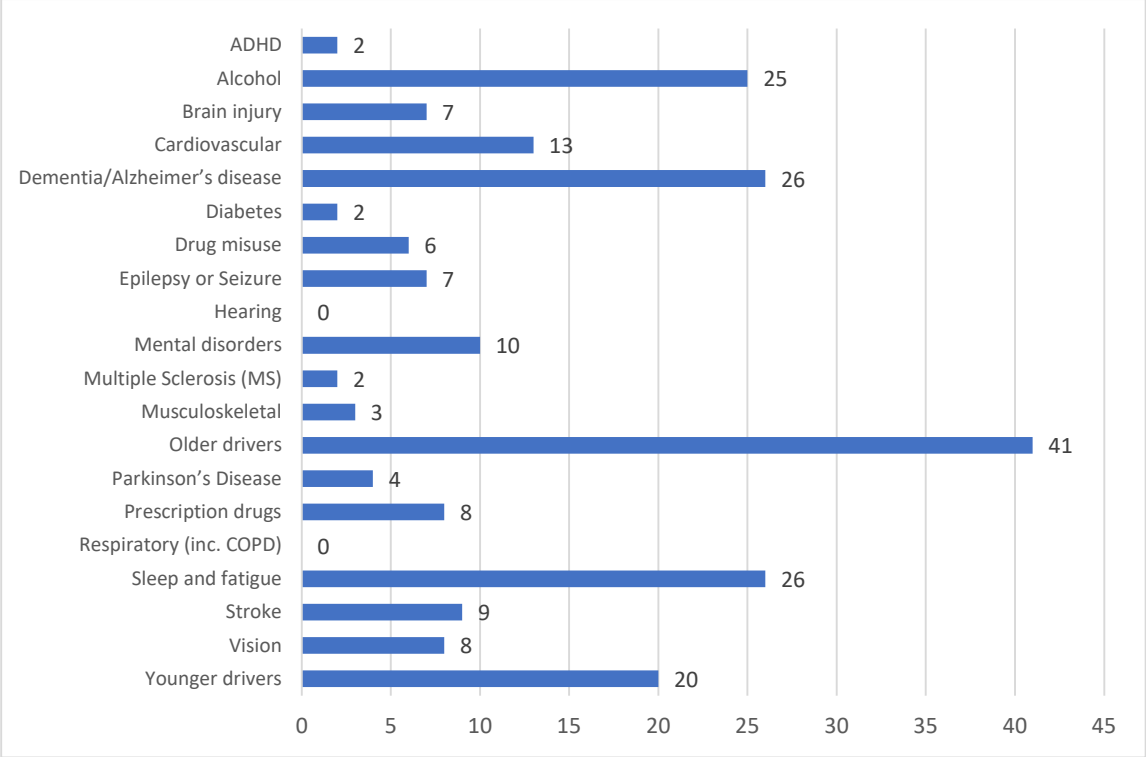

Figure 3 Number of systematic reviews with data extracted by condition/topic

6.3 Grey literature

The grey literature was in a variety of formats, mostly as reports, but sometimes as website pages. In total we identified 176 reports which appeared relevant to this scoping review. After screening we included 121 reports in the review (PRISMA flow diagram in **Appendix I** gives details). The data extraction form was not used for these as they often did not follow the reporting format used by articles published in academic journals. Instead, these were read and the conclusions and recommendations were summarised.

7. Summary of the research evidence on fitness to drive by condition or topic

We reviewed the evidence from both the published literature (223 systematic reviews) and grey literature (121 reports) in relation to the following medical conditions and topics.

7.1 Alcohol misuse

Alcohol ingestion and intoxication is associated with a high proportion of motor vehicle collisions (MVCs), and we found a significant number of articles on alcohol related driving. The DVLA divide alcohol into four categories: alcohol misuse, alcohol dependence, alcohol related disorders, and alcohol related seizure (DVLA, 2021). The DVLA define alcohol misuse as 'a state that causes, because of consumption of alcohol, disturbance of behaviour, related disease or other consequences likely to cause the patient, their family or society present or future harm and that may or may not be associated with dependence. The Monash group use the term alcohol use disorder (AUD). DVLA licensing rules for alcohol misuse are that Group 1 drivers must not drive and must notify DVLA, the licence will be refused or revoked until after a minimum of 6 months of controlled drinking or abstinence, and normalisation of blood parameters. For Group 2 drivers the minimum period of abstinence is one year.

The literature search identified 4995 papers on alcohol and driving. Of these, Endnote software identified 93 systematic reviews. After screening, 25 reviews met the inclusion criteria for data extraction. A number of the articles then overlap with other conditions or areas elsewhere discussed in this report, namely with drug misuse and with young drivers.

All of the systematic reviews focussed on alcohol misuse, with only the Monash report presenting findings on alcohol use disorders. We included a report by Solomon et al (2009) showing national statistics for alcohol, trauma and impaired driving. Defining alcohol use disorders can be problematic if articles do not state whether individuals with alcohol use disorders were included or not and/or if the research in those cases included both alcohol misuse and alcohol-use disorders into one category. Added to this is the wider issue around the line between alcohol misuse and an alcohol-use disorder.

7.1.1 Alcohol misuse, injury and driving behaviour

A report by Solomon et al (2009) analyses the national statistics on alcohol, trauma and impaired driving. The report, whilst based in Canada, also provided UK statistics. There were an estimated 460 alcohol-related road fatalities in 2007, the same number as in 1999. On average, there are 200-300 road fatalities per year associated with BACs (blood alcohol concentration) between .01% and .08%. In 1998, an estimated 80 fatalities were attributable to BACs between .05% and .08%. More than 90% of convicted drinking drivers were male and 52% were under the age of 33. Approximately 50% had BACs above 15%, and 12% were convicted of a second offence within 10 years. About 50% of vehicle occupants killed between 10 p.m. and 4 a.m. have BACs ≥ .08%. On Friday and Saturday nights, this proportion rises to 60%.

The most common mode of sustaining an alcohol-attributable injury is from a single occasion of acute alcohol consumption, but much of the injury literature employs usual consumption habits to assess risk instead (Taylor et al., 2010). As a result, the review by Taylor et al examined the dose-response relationship between alcohol and injury to generate single occasion- and dose-specific relative risks to address the gap. The results showed risk of injury increases non-linearly with increasing alcohol consumption. For motor vehicle accidents, the odds ratio

increases by 1.24 per 10-gram in pure alcohol increase to 52.0 at 120 grams. The researchers concluded that efforts to reduce drinking, both on an individual level and a population level, are important, and that 'no level of consumption is safe and even for 2 standard drinks, the odds of injury are almost double for most types of injury.' Abstinence was related to the lowest risk. The authors suggested that policy measures such as taxation, raising legal drinking ages, and efforts to reduce acute alcohol consumption and associated injury, are to be encouraged and implemented given the high risks associated with acute alcohol consumption.

Yadav et al (2021) recently reviewed the laboratory-based research on the effects of alcohol and driving behaviour. The majority of the studies were found to have been conducted in the USA (45%), followed by Australia (15%). These studies were reviewed based on the following aspects: type of driving simulator, study design, BAC or alcohol dose used in the experiments, driving environment characteristics, driving performance measures, data analysis techniques, and additional factors affecting driver behaviour under the influence of alcohol. Overall, the evidence regarding driving performance under the influence of alcohol shows that the majority of previous studies have found a significant impact of alcohol on the various aspects of driving behaviour. At the time of this review, the authors suggested a large number of research gaps and future research avenues, including that there was no comparative analysis that critically assesses the differences in the way alcohol influences the driving behaviour among the drivers of developed and developing nations.

In terms of future research, they suggested the comparison of alcohol-impaired driving performance between the drivers of developing nations with the drivers of developed nations to gain insight into the inter-country differences. Though alcohol is known to influence the drivers' attention on manual tasks involved in automated driving, drinking and driving is not yet considered as a significant issue of research in the context of automated driving. Similarly, investigations on the interaction of alcohol and road environment/infrastructure would further enhance the understanding of driving behaviour under the influence of alcohol with respect to varying environmental conditions. To comprehend why the driver tends to engage in the act of drinking and driving even after knowing about the consequential effects of alcohol, it is also important to investigate the influential factors which have the potential to motivate drivers to engage in the act of drinking and driving. Understanding the psychological viewpoint of drivers which persuades them to alcohol-impaired driving is an important area of research. Moreover, future research should consider conducting face-to-face interviews of traffic police officials and policymakers to obtain their feedback and understand the difficulties faced by them in handling the drink and drive offences. Also, the effectiveness of traffic regulations, law enforcement, policy implementations, and road safety awareness campaigns in reducing alcohol-influenced road crashes need to be examined at the country level as well as the global level, along with more research on the attitudinal behaviour of drink and drive offenders and reoffenders. In addition, understanding drink driving patterns in the post-COVID world where the authors suggest driving patterns have changed as a result of the pandemic.

7.1.2 Alcohol and cognitive performance when driving

Two other reviews have looked specifically at alcohol and cognitive performance when driving (Garrison et al, 2021), one including the next-day effects, or 'hangover effects', after heavy consumption also examined in a meta-analysis (Gun et al., 2018). In the overall study on cognitive impairment, the authors found that each of the cognitive domains assessed in this review showed impairment at blood alcohol concentrations equal to or below the legal driving limit in many jurisdictions (Garrison et al 2021). The authors also suggested future research could determine the effects of alcohol on cognitive functioning with greater accuracy by

employing more consistent, reliable and comparable measures while considering the translation of deficits to real-life driving. In the Gun et al review, the results suggested that sustained attention and driving abilities were impaired during hangover. Mixed results were observed for psychomotor skills, short- (STM) and long-term memory (LTM) and divided attention. The meta-analysis revealed evidence of impairments in STM; LTM; sustained attention; and psychomotor speed during alcohol hangover. In relation to future research, the authors made three recommendations: 1) that the shortcoming of low statistical power be addressed, and studies should conduct a power analysis to determine an estimate of required sample sizes; 2) consideration should be given for the use of reaction time as an outcome measure in tasks, and interpretation should acknowledge the potential impact of next-day psychomotor impairments; 3) future research should seek to address the paucity of robust research examining executive functions the morning following a night of heavy alcohol consumption.

7.1.3 Alcohol and wider level public policy

Other work on wider level public policies has reviewed the effect of alcohol trading days (Middleton et al., 2010) and trading hours (Sanchez-Ramirez et al, 2018). The evidence from the Middleton et al review indicated that increasing days of sale leads to increases in excessive alcohol consumption and alcohol-related harms and that reducing the number of days that alcoholic beverages are sold generally decreases alcohol-related harms.

The effect of police patrols has also been reviewed. Goss et al (2008) incorporated 32 studies which had evaluated increased police patrols, either alone or combined with other interventions, targeting alcohol-impaired motor vehicle drivers. The study types were randomized controlled trials, controlled trials, controlled before and after studies, interrupted time series (ITS) studies, and controlled ITS studies. The authors concluded that increased police patrol programs were generally consistent in reporting beneficial effects on traffic crashes and fatalities, but study quality and reporting were often poor. They recommended that good quality controlled studies with adequate sample size are needed to evaluate increased patrols. Also needed are studies assessing the cost-effectiveness of this intervention.

7.1.4 Alcohol and drugs testing in occupational drivers

Workforce alcohol and drug testing is commonplace but its effect in reducing occupational injuries remains unclear (Cashman et al., 2010). The Cochrane review by Cashman reviewed two previous studies and the findings from one study suggested that 'in the long term, random drug testing was associated with a significant increase in the downward trend (-0.19 injuries/100 person years/year, 95% CI -0.30 to -0.07). The other study was also associated with a significant improvement in the long-term downward trend (-0.83 fatal accidents/100 million vehicle miles/year, 95% CI -1.08 to -0.58).' The review however concluded that there is insufficient evidence to advise for or against the use of drug and alcohol testing of occupational drivers for preventing injuries as a sole, effective, long-term solution in the context of workplace culture, peer interaction and other local factors.

7.1.5 Alcohol use disorders and motor vehicle crash risk

In the Monash review of alcohol use disorders (AUDs) and MVC risk, eight studies were included, but the quality of evidence was variable, three studies were rated 'good', four 'fair' and one 'poor'. No studies examined on-road driving performance. Six studies reported an increased risk of MVC for drivers with AUD, and one study reported a reduced risk. The review

authors recommended that AUD should be considered a risk for MVC, and highlighted the need for ensuring accurate diagnosis of AUD. They recommend treatment and follow-up for drivers with AUD and those involved in traffic violations and MVC. The authors called for further research linking medically diagnosed AUD with MVC risk, and routine referral of those detected as driving with impairment with alcohol for diagnosis and follow-up in audited studies.

7.2 Cardiovascular conditions

The DVLA guide for medical professionals provides driving rules for a long list of cardiovascular disorders. Group 1 drivers with angina must not drive when symptoms occur: at rest, with emotion, or at the wheel, but need not notify DVLA and driving may resume after satisfactory symptom control. For several conditions the driving restrictions are short-lived and somewhat complicated, for example patients must not drive for at least one week after pacemaker implant or pacemaker box change. They must notify DVLA of pacemaker implantation, not after a pacemaker box change. For patients with aortic aneurism Group 1 licence holders may drive and need not notify DVLA if aneurysm diameter is less than 6cm. Such requirements show that it is important for health professionals to advise patients correctly.

The literature search identified 1236 papers on cardiovascular conditions and driving, of these Endnote software identified 43 systematic reviews. After screening, 13 reviews met the inclusion criteria for data extraction though the vast majority fitted into other conditions areas, leaving one specifically relating to cardiovascular disease and driving, however this study's conclusions were more related to the impact of prolonged car use and the detrimental effects of this with obesity which is itself a cardiovascular risk. The review nevertheless is detailed below.

A review by Sugiyama et al (2020) included nine studies (five examined cross-sectional associations, three examined longitudinal associations, and one examined both). One study found longer car use to be related to higher risk of cardiovascular disease as a cause of death. Six out of six cases examining relationships of car use duration with obesity-related outcomes reported significant detrimental associations. However, car use frequency was associated with obesity outcomes in only one out of four cases. Findings were mixed or null for other cardiovascular disease risk markers (blood glucose, blood lipids, blood pressure and composite risk indices. Studies examining effect modification by gender and age found associations of car use with obesity to be more pronounced in men and working-age adults, relative to women and older adults. The authors concluded that they had found strong evidence supporting detrimental associations of prolonged car use with obesity. However, none of the studies used device-measured time spent sitting in cars.

7.3 Diabetes

According to the International Diabetes Federation (IDF) (2021) 1 in 10 adults worldwide are living with diabetes, representing 537 million adults (20-79 years). This number is predicted to rise to 643 million by 2030. Globally, in 2021 the prevalence of diabetes was 9.8%, but among adults aged 75–79 years diabetes prevalence was estimated to be 24% (IDF, 2021). In Europe the figure is 1 in 11 (61 million adults), rising to a predicted 67 million by 2030. One in three adults living with diabetes are undiagnosed (IDF, 2021). In the UK, in 2021, there were approximately 4 million adults with diabetes, with a prevalence of 6.3% (IDF Diabetes Atlas 10th Edition, 2021). Prevalence of diabetes increases with age, so with the aging population numbers are expected to rise significantly.

A number of complications are associated with diabetes which can negatively affect FTD. These include cardiovascular disease, peripheral neuropathy, and visual complications. A

major concern for drivers with diabetes on insulin is hypoglycaemia which can cause confusion, slowed reaction times and potential loss of consciousness.

The literature search identified 438 papers on diabetes and driving, of these, Endnote software identified 16 systematic reviews. Most overlapped with other areas and were not relevant. After this screening, two reviews met the inclusion criteria for data extraction:

A review by Graveling et al (2015) focuses mainly on drivers who require insulin treatment for their diabetes. The authors suggested that although the magnitude of the effects of hypoglycaemia while driving on accident risk continues to be debated, hypoglycaemia undoubtedly does cause road traffic accidents, some of which have a fatal outcome. Patients prone to debilitating hypoglycaemia (such as those with impaired awareness of hypoglycaemia) should therefore merit special consideration from the licensing authorities. They therefore concluded that the 'adoption of a more individualized approach to the assessment of the medical fitness to drive in North America and in Europe has been an enlightened and commendable development in recent years, but still requires further refinement to ensure its safe and effective application.'

Bieber-Tregear et al (2011) carried out a systematic for the Federal Motor Carrier Safety Administration (US), with a focus on commercial motor vehicle (CMV) driving and diabetes. They found only one study which included a population of CMV drivers which addressed the primary question 'Are individuals with diabetes mellitus at increased risk for a motor vehicle crash when compared with comparable individuals who do not have diabetes?'. For the secondary question: 'Is hypoglycaemia an important risk factor for a motor vehicle crash among drivers with diabetes mellitus?' 27 studies were included. The authors identified many methodological limitations in the included studies. None examined task performance in a population of CMV drivers. Consequently, the degree to which the findings of the included studies, particularly findings related to specific driving skills, can be generalized to professional drivers is unclear. Also, none of the studies enrolled individuals with type 2 diabetes, yet the prevalence of type 2 diabetes in the general population is considerably higher than that of type 1 diabetes. It is unclear if the effects of hypoglycaemia on cognitive performance, psychomotor function, and driving performance are comparable between individuals with type 1 and type 2 diabetes. The review findings were therefore inconclusive. Future research should investigate the relationship between diabetes and MVC for commercial drivers using well controlled studies which include patients with both type 1 and type 2 diabetes.

In the Monash review of diabetes and MVC risk, six studies were included. Of the six studies, three reported a small increase in MVC risk when drivers with diabetes without complications are compared to drivers without diabetes, and three studies reported no difference in MVC risk. Drivers with diabetes who are unable to recognise an imminent hypoglycaemic episode are at particular risk of a MVC. The authors concluded that the identification of drivers susceptible to experience hypoglycaemia whilst driving should be a priority and recommend educating drivers with diabetes to identify and react to the signs of an impending hypoglycaemic attack.

The Older Driver Task Force (2021) recommended that future research on physical and medical conditions affecting FTD, placing particular emphasis on research into diabetic peripheral neuropathy and driving as this may contribute to pedal confusion (mistaking the accelerator for the brake) which can lead to severe MVCs.

7.4 Driver age

7.4.1 Older Drivers

In 2021, in Great Britain, drivers aged 65 and over accounted for 22% of all licence holders (8,943,529) and this figure, in line with an ageing population, is increasing every year by around 250,000 (DfT, 2022). Access to a car and the ability to drive is important for continuing mobility and quality of life for older drivers.

The literature search identified 3148 papers on older, or aged drivers, of these Endnote software identified 73 systematic reviews. After screening, 41 reviews met the inclusion criteria for data extraction. There are far too many reviews to summarise here. Many reviews overlapped with other conditions (medications, vision, dementia, cognitive impairment, and diabetes). Several reviews examined driving cessation. Several reviews examined assessment measures for FTD. Three reviews are summarised below:

Mielenz et al (2016) carried out a review of the literature on select physical performance measures and driving outcomes in older adults. This review formed part of the US LongROAD Study. The objective of the review was to assess the evidence in the research literature on the association of three validated lower extremity strength and balance physical functioning measures and driving outcomes in older adults, including: driving exposure, cessation, crashes, citations, and ability. The three measures include one battery and two standalone measures: the Short Physical Performance Battery (SPPB), the Timed Up-and-Go Test (TUG), and the Rapid Pace Walk (RPW). Thirteen studies were included in the review involving 5,313 older adults. Based on the review, lower SPPB scores are associated with reduced driving exposure and increased cessation, poorer RPW scores are associated with decreased driving ability in some studies and reduced driving exposure in one study, and TUG scores are not associated with any driving outcomes. The authors concluded that future driving studies should consider using the SPPB to determine if there is an association between SPPB scores and driving outcomes, and that the SPPB may be useful as a risk factor assessment for identifying individuals at risk of reducing their driving exposure and driving cessation.

Rapoport and Cameron (2014) carried out a systematic review of antidepressants and driving in the elderly. The rationale for the review was that the potential effects of psychoactive drugs on motor vehicle operation have been investigated in recent literature, but many studies focus on a young or middle-aged population. Many seniors are diagnosed with depressive disorders, for which antidepressant drugs are commonly prescribed medications, and the increasing number of senior drivers makes the possible consequences of antidepressant use on driving skills in a senior population a pressing issue. Thirty-six studies were included in the review, but only 6 studies addressed a senior population. The authors concluded that there is a lack of concerning the effects of antidepressants on driving performance in the elderly. They recommended that future research be carried out in this area.

Scott et al (2017) carried out a systematic review and meta-analysis on falls and driving outcomes in older adults. The review objective was to examine associations between falls and subsequent motor vehicle crashes (MVCs), crash-related injuries, driving performance, and driving behaviour. Fifteen studies were included in the review. Results showed that a fall history was associated with a significantly greater risk of subsequent MVC. One study found a significantly greater risk of MVC-related hospitalizations and deaths after a fall. There was no conclusive evidence regarding an association between falls and driving cessation and showed no association between falls and driving performance or behaviour. The authors concluded that falls in older adults appear to be a risk marker for subsequent MVCs and MVC-related injury, however as these results are based on observational studies, the identified associations may

also result at least partly from confounding or bias. They recommend future research should clarify the mechanisms linking falls to crash risk and to develop effective interventions to ensure driving safety in older adults with a history of falls.

In addition to the published articles, we included reports from the 'grey literature':

The long running prospective Candrive project on older drivers in Canada (funded by CIHR) and the Ozcandrive project in Australia and New Zealand (funded by the Australian Research Council) are excellent examples of research into older drivers put to practical use and changing policy. Candrive has had an impact on policy for older drivers in Canada. The Candrive research aims are to: 1) Increase understanding of the natural history of driving in those over 70 years; 2) Measure the impact of medical and functional conditions on crash rates; 3) Develop clinical tools that identify older persons who are and are not at risk of future crashes and those who need to undergo further in-depth testing of driving ability; 4) Develop and evaluate the effectiveness of driver retraining and education programs; 5) Clarify the role of on-road and driving simulator testing in the process of older driver assessment; 6) Lessen the difficulties associated with the transition to non-driving; and 7) Assist seniors to identify and use automobile technological innovations to their advantage.

In Australia, Austroads has invested in research into older drivers. In 2003 they published a report on self-regulation of older drivers (Austroads, 2003). This report reviewed the literature on the process of reduction and cessation of driving and discussed the importance of this behaviour to reduce the incidence and severity of crashes involving older drivers. The review also identified a number of factors that influence and hinder the adoption of self-regulatory behaviours. Inhibitory factors include lack of insight into one's own physical status and functional ability; lack of awareness of the impact of ageing on driving performance; inappropriate risk assessment; perception of loss of independence; lack of available alternative transport; and reluctance to become dependent on others.

Austroads has funded the Older Driver Model Assessment Program (ODMAP) since 2000. This is a multi-stage project. Stage 1 developed an older driver licensing model that moved away from mandatory age-based assessment of FTD, by restricting assessment to those older drivers showing some evidence of being at heightened crash risk. Stage 2 evaluated a series of screening tests against performance on a specially-designed on-road driving test as an initial measure of test validity. Stage 3 involved a field trial to determine whether the proposed licensing model and one of the screening tests from Stage 2 were feasible to operate in the context of a licensing office. Stage 4 had the primary purpose of evaluating the capacity of a set of 16 assessment protocols to distinguish between older drivers recently involved in at-fault crashes and older drivers not involved in crashes. To be operable, the proposed Austroads licensing model requires a set of valid assessment protocols able to distinguish between safe and unsafe drivers, with the required measure of validity varying according the level of assessment. At the end of stage 4 the authors found that there is no evidence that the screening tests used were able to distinguish between safe and unsafe drivers, and concluded that the tests are unlikely to be useful to licensing authorities. They recommended that more effective assessment protocols and associated processes be developed; and that future research should involve an international older driver cohort study with the aim of identifying/developing and evaluating a battery of both on-road and off-road assessment protocols (Austroads, 2009).

In the UK, Gandolfi (2020) examined the literature on 'age-related driver impairment relationships between vehicle technology and driver stress and confidence, and the effectiveness of interventions intended to mitigate the risk-increasing effects of age-related declines in physical and cognitive processes'. The subsequent report focused on factors that

increase the risk for older drivers, how emerging vehicle technology can help to mitigate these risks, and what tools and strategies are available to improve self-awareness of older drivers and help them to use self-regulation processes effectively and appropriately. Gandolfi concluded that the traffic environment is already relatively well engineered for older drivers, and although systems approaches to risk management are popular, she recommended that instead older drivers should be helped to act safely in terms of their interactions and decision-making both within the traffic environment and the self-regulation process. With appropriate training and guidance emerging vehicle technology can offer significant safety benefits for older drivers but the road safety industry should help them use if effectively.

Also in the UK, Lang et al (2013) reviewed the evidence on the role of self assessment tools for older drivers. Self-assessment tools provide drivers with feedback on their driving abilities and give advice on how safe mobility can best be maintained. The authors made several recommendations for future research, including: evaluation of how the outcomes of self-assessment tools impact older drivers' actual self-regulation, and the impact on their safety on the road; validation of self-assessment tools, particularly in the areas of risk-taking and situation awareness; randomised controlled trials are needed to refine self-assessment tools for use with older drivers of different pathologies and experience levels; and higher cognitive functions, such as hazard perception and change blindness in older drivers, should be included in self-assessment tools.

In their 2016 report the Older Driver Task Force made two recommendations regarding FTD. One was that the DVLA should require evidence of a recent eyesight test at licence renewal. The current system only requires the applicant to tick a box confirm that their eyesight meets current standards (reading a car number plate at 20 metres). The UK eyesight standards are among the most lenient in Europe (European Council of Optometry and Optics (2017)). The second recommendation was that driver appraisal schemes should be offered to older drivers as these have the potential to become a social norm for any responsible older driver to refresh the skills and knowledge needed to support safe driving into old ages. However, currently there are many schemes available of variable quality. It was recommended that a core content and quality standard for driving appraisals be developed.

In 2021 the Older Driver Task Force published the second edition of their report. The group reinforced their earlier recommendations and added more detail. For eyesight they recommend the introduction of mandatory eyesight testing with an optometrist or ophthalmic/medical practitioner providing a driver 'MOT' of eyesight at licence renewal at the age of 70 and at subsequent renewals. The group repeated their recommendation for driving appraisals for older people, adding that a recent training course for approved driving instructors on older drivers should be extended to create a pool of certified instructors with particular expertise in assessing older drivers. They also introduced a recommendation for future research into the impact of physical and cognitive medical conditions on FTD. They placed emphasis on diabetic peripheral neuropathy which may contribute to pedal confusion events to which older drivers seem particularly vulnerable.

A UK report by Berry (2011) considered whether older drivers could be 'nudged' into self regulation by public and private sectors. The study considered how interventions, or 'nudges', based around insights from behavioural economics and psychology can be used to assist older drivers in coping with the ageing process. Berry argued that the task of policymakers is to make self-regulation more effective. He recommended that the process of self-regulation should be improved by providing older people with the advice, tools, and incentives to make decisions appropriate to their own circumstances. He made further recommendations regarding health professionals which are discussed in section 7.16 below.

7.4.2 Younger Drivers

In 2021, in Great Britain, there were just under three million drivers aged 25 and under (2,933,443) accounting for 7% of all licence holders (DfT, 2022). Motor vehicle crashes are also a leading cause of death for adolescents and young adults. Driver inexperience is considered to be one of the underlying reasons for the high risk of road crashes involving young drivers.

The literature search identified 3162 papers on young, teen or novice drivers, of these Endnote software identified 55 systematic reviews. After screening, 20 reviews met the inclusion criteria for data extraction.

Cassarion et al (2018) reviewed the literature on young novice drivers, including empirical studies, systematic reviews, and crash reports published over the past ten years to provide a synthesis of risk and protective factors across multiple domains, from individual characteristics, to social influences, to behavioural and social interventions, to the car and road environment. The authors discussed links between these domains to clarify the strongest indicators of risk for young novice drivers as compared to experienced drivers, and collated the available evidence on social and environmental factors that can improve young drivers' behaviour so to reduce the rate of their road crashes. Among the factors discussed, the incomplete maturation of cognitive skills crucial to safe driving (visual scanning, hazard anticipation, handling of in-vehicle distractions) and the higher susceptibility to social influences (especially peers and parents) emerged as the strongest determinants of discrepancies in performance between young novice and experienced drivers. The authors suggested that 'growing awareness of the complex array of factors intervening synergistically in young drivers' risk, as well as technological advancements have led to the design of interventions with some level of effectiveness, however, further research and more robust programmes adopting ecological and holistic approaches are needed to fully address the young driver problem.'

Banz et al (2021) looked at the state of the art in relation to understanding brain mechanisms and driving behaviour in younger drivers. The authors found the potential feasibility of coupling neuroscience with driving simulation to study the neuro-correlates of driving behaviours in the context of young drivers and neuromaturation. The findings showed that, to date, most research has focused on examining brain correlates and driving behaviours related to contributing factors for fatal motor vehicle crashes. In the identified studies, there were primarily two areas of investigation pursued; driving impairment and distraction in driving. Impairment studies primarily explored the areas of drowsy/fatigued driving or alcohol-impaired driving. Studies of distracted driving primarily focused on cognitive load and auditory and visual distractors. As such, there remains a 'considerable paucity of research' designed to understand underlying brain mechanisms that might otherwise facilitate greater understanding of individual variability of normative and risky driving behaviour within the young driving population.

Roberts et al (2001) reviewed the literature to quantify the effect of school-based driver education on licensing and road traffic crashes. The results showed that driver education leads to early licensing but they found no evidence that driver education reduces road crash involvement, and suggest that it may lead to a modest but potentially important increase in the proportion of teenagers involved in traffic crashes. A limitation was that the included studies included trials conducted between 1982 and 1984. The authors concluded that the results may not results be generalisable to contemporary driver education programmes.

Martín-delosReyes et al (2019) undertook a systematic review of previous studies designed to determine whether the use of a driving simulator for passenger cars or motorcycles in young novice or learner drivers leads to a reduction in road crashes and/or traffic infractions, or to the acquisition of safer driving skills, compared to non-use of driving simulators. Overall, the quality

of the studies was poor and the results were inconsistent across studies regarding the major outcomes. The authors concluded that the review did not provide evidence to support or refute the efficacy of training programs based on simulators for young learner or novice drivers in improving the safety of their driving styles. They recommended that additional controlled studies are needed to overcome the limitations of research designs used thus far.

A review by Dénommée et al (2020) examined mobile phone use in younger drivers. Three categories were created based on recurrent topics from the literature (29 studies): self-reported behaviours and attitudes, simulation and naturalistic studies, and prevention. The literature suggested that texting while driving effects drivers' visual scanning of the road; their ability to maintain speed, headway, and lane position; and their ability to follow lane change signs, causing an increased risk of driving collisions. There was evidence that this behaviour predicts other risky driving behaviours such as speeding while talking on the phone. Furthermore, any form of conversation, including hands free, can be distracting to the driver. Interestingly, drivers are aware of the risks and dangers, yet continue to engage in the behaviour. It was concluded that 'young drivers have a lower risk perception of engaging in such risky behaviours which helps explain the prevalence of texting and driving among these individuals. Mobile phone use while driving clearly remains a prevalent issue among this age group, which highlights the importance of addressing this matter.' The authors recommended that future work is needed to develop effective prevention strategies and also evaluate the effectiveness of any current and future prevention strategies to deter texting and driving among individuals most at risk for engaging in such behaviours.

7.5 Drugs and driving

7.5.1 Drug misuse

The DVLA (2021) identify a range of categories of drugs related to misuse or dependence. In most cases drivers with drug misuse or dependence must not drive and must notify DVLA with persistent misuse or dependence. Medical enquiry confirming the problem will result in the licence being refused or revoked for a minimum of six months (Group 1) or a minimum of one year (Group 2) which must be free of misuse or dependence. There are special notes for medical practitioners on the prescribed use of therapeutic drugs such as benzodiazepines, which state that recommended therapeutic doses do not amount to persistent misuse or dependence for licensing purposes (noting however that clinical dependence may exist). It is well-established that driving under the influence of alcohol increases the risk of accident involvement. However less is known about the effects of drugs (medicinal or illicit) on the risk of accident involvement (Elvik et al., 2013).

The literature search identified 696 papers on drug misuse and driving, of these, Endnote software identified 34 systematic reviews. After screening, six reviews met the inclusion criteria for data extraction. Three of the articles also covered alcohol (one of which is discussed above in section 7.1).

Two reviews focussed on the effect of cannabis use on driving (Raemakers et al., 2004 and more recently Hostiuc et al., 2018). The more recent work by Hostiuc et al (2018) reported significant increases in the effect size for DUIC (driving under the influence of cannabis) as tested through blood analysis, with an odds ratio (OR) of 2.27 and a confidence interval (CI) between 1.36 and 3.80; death as an outcome, with an OR of 1.56 and a CI between 1.16 and 2.09; and case-control as the type of study, with an OR of 1.99 and a CI between 1.05 and 3.80. However, publication bias was very high (the tendency from authors and journals to publish studies with significant results). In addition, the authors' analysis suggested that the overall

effect size for DUIC on unfavourable traffic events was not statistically significant, but there were significant differences obtained through subgroup analysis. This result might have been caused by either methodological flaws (which are often encountered in articles on this topic), the indiscriminate employment of the term "cannabis use," or an actual absence of an adverse effect.

Another review examined the effect of psychoactive drug use among truck drivers (Dini et al., 2019). Few studies had assessed the extent of psychoactive drug consumption in the occupational setting. Psychoactive substance use has a relevant impact on the drivers' health and safety, increasing the risk of injuries and traffic accidents, potentially affecting the general public health as well. The results showed a prevalence of overall drug consumption of 27.6% particularly high considering illicit CNS-stimulants (amphetamine consumption of 21.3%, and cocaine consumption of 2.2%, and that it appeared that truck-drivers choose stimulant substances as a form of performance enhancing drug, in order to increase productivity. However, chronic and high dose consumption has been shown to decrease driving skills, placing these professional drivers at risk for health and road safety. The authors concluded that further research is required, particularly in Europe, in order to fill the knowledge gap and improve the strength of evidence in this area.

7.5.2 Prescription medicines/drugs

Driving under the influence of prescription and over-the-counter medication is a growing public health concern. Each year over one billion prescription items are dispensed from pharmacies in England alone (Statista, 2022). Medicines that can seriously impair driving (antidepressants, opioids, gabapentinoids, benzodiazepines, and sleeping tablets) were prescribed for 16.8 million people in England in the financial year 2017/18 (Public Health England, 2020).

The literature search identified 80 papers on prescription drugs/medications and driving, of these, Endnote software identified 12 systematic reviews some of which overlapped with other related condition areas (alcohol, drug misuse, mental conditions and epilepsy/epilepsy drugs withdrawal). Data were extracted from eight systematic reviews:

Elvik et al (2013) reviewed the use of both illicit and prescription drug use. The review incorporated 66 studies which reported the odds ratio of accident involvement for amphetamines, analgesics, anti-asthmatics, anti-depressives, anti-histamines, benzodiazepines, cannabis, cocaine, opiates, penicillin and zopiclone (a sleeping pill). The results suggested for most of the drugs, small or moderate increases in accident risk associated with the use of the drugs were found. However information about whether the drugs were actually used while driving and about the doses used was often imprecise. Most of the studies that evaluated the presence of a dose-response relationship between the dose of drugs taken and the effects on accident risk confirmed the existence of a dose-response relationship. The findings also found that the use of drugs while driving tends to have a larger effect on the risk of fatal and serious injury accidents than on the risk of non-injury accidents. However, the quality of the studies that have assessed risk varied greatly and there was a tendency for the estimated effects of drug use on accident risk to be smaller in well-controlled studies than in poorly controlled studies. The authors concluded the associations found cannot be interpreted as causal relationships, principally because most studies do not adequately control for potentially confounding factors, thus suggesting a need for future research which addresses confounding factors.

Rudisill et al (2016) reviewed studies on prescription drugs, incorporating 27 studies of 53 medications. Fifteen (28.3%) were associated with an increased risk of MVC. These included Buprenorphine, Codeine, Dihydrocodeine, Methadone, Tramadol, Levocitirizine, Diazepam, Flunitrazepam, Flurazepam, Lorazepam, Temazepam, Triazolam, Carisoprodol, Zolpidem, and Zopiclone. The authors however concluded that associations between specific medication use and the increased risk of MVC and/or affected driving ability are complex. Future research could therefore address these associations.

Dassanyake et al (2011) reviewed the effects of benzodiazepines, psychotropic medications and therapeutic opioid agonists, thus incorporating 90 studies. Two meta-analyses showed that benzodiazepines to be associated with a 60% to 80% increase in the risk of traffic accidents and a 40% increase in 'accident responsibility'. Co-ingestion of benzodiazepines and alcohol was associated with a 7.7-fold increase in the accident risk. Subgroup analysis of case-control studies showed a lower benzodiazepine-associated accident risk in elderly (>65 years of age) drivers than in drivers <65 years of age, a result consistent with age-stratified risk differences reported in cohort studies. Anxiolytics, taken in single or multiple doses during the daytime, impaired driving performance independent of their half-lives. With hypnotics, converging evidence from experimental and epidemiological studies indicates that diazepam, flurazepam, flunitrazepam, nitrazepam and the short half-life non-benzodiazepine hypnotic zopiclone significantly impair driving, at least during the first 2-4 weeks of treatment. The accident risk was higher in the elderly (>65 years of age) who use tricyclic antidepressants (TCAs); however, the evidence for an association of antidepressants with accident risk in younger drivers was equivocal. Sedative, but not non-sedative, antidepressants were found to cause short-term impairment of several measures of driving performance. Limited epidemiological research reported that opioids may be associated with increased accident risk in the first few weeks of treatment. The authors concluded benzodiazepine use was associated with a significant increase in the risk of at-fault traffic accidents, and that the association was more pronounced in younger drivers. Accident risk was also markedly increased by co-ingestion of alcohol. Driving impairment was generally related to plasma half-lives of hypnotics, but with notable exceptions. Anxiolytics, for example, with daytime dosing, impaired driving independent of their half-lives. TCAs appeared to be associated with increased accident risk, at least in the elderly, and caused short-term impairment in driving performance. Opioid users may also be at a higher risk of traffic accidents; however, experimental evidence is limited on their effects on driving.

Smink (2010) carried out a systematic review of benzodiazepines and crash risk. Across the 66 studies included in the review, the results indicated that the highest risk for accidents occurred within the first weeks after the index prescription fill date. The risk associated with benzodiazepines seemed to be higher with anxiolytics compared with hypnotics, and with agents with a long half-life compared with an intermediate half-life. There was also evidence for a dose-effect relationship between benzodiazepine use and accident risk. However, the authors suggested that the divergent study designs, study populations and comparison groups and the variety of methods used to express the outcome of interest hampered a comparison between results and prevented making an accurate estimate of the strength of the association between benzodiazepine use and traffic accidents or related outcomes. Some of the epidemiological studies included in the review seemed to present conflicting results, and the authors questioned whether or not discrepancies can be explained by differences in methodological factors like study population, exposure measure, outcome or study design. Similarly, they concluded that more research should be conducted to clarify the relationship between benzodiazepine use and culpability, given an accident.

Ménard et al (2008) and Rapoport et al (2007) reviewed psychotropic medications on FTD, and driving in simulated environments respectively. The study by Ménard et al included 14 studies with people with mental illnesses. In eight, mental illness was linked to higher traffic accident rates. The authors suggested that some psychotropic medications have the potential to negatively affect fitness-to-drive, especially in the starting phase of treatment, or when adjusting medications, and that newer antidepressants have been shown to improve specific pre-requisite skills for driving. Although newer antipsychotic medications improve cognitive skills, these improvements do not translate into driving-related tasks. The authors concluded that accident rates are higher among sub-groups of individuals including those having the most severe degree of mental illness and those using specific psychotropic medications such as benzodiazepines. In terms of future research needed in this area, the authors suggested standardized screening and assessment of fitness-to-drive in psychiatric patients, and the creation of guidelines that assist clinicians in their daily decision-making.

Rapoport et al (2007) also suggested similar findings (though the results of the studies were quite variable) whereby benzodiazepines and TCAs were most commonly associated with impairment, although the level of impairment was dependent on the population studied, the dose and the time of testing relative to drug administration. They also suggested that as newer, more sophisticated computer driving simulators become available, standardisation of protocols and validation will be priorities and, ultimately, this approach should offer a useful and safe laboratory measure of drug-related changes in driving ability.

Brunnauer et al (2017) reviewed experimental and clinical studies on the effects of antidepressants on driving performance. Their analysis concluded that most tri- and tetracyclics have acute deleterious effects on driving performance that, except for mianserin, reduce after sub-chronic use. Selective serotonin reuptake inhibitors (SSRIs) and the serotonin norepinephrine reuptake inhibitors venlafaxine and milnacipran did not affect driving ability. Trazodone however appeared to have dose-related acute effects on driving skills. Acute use of mirtazapine does produce impairments that diminish when given as a nocturnal dose and cannot be seen in healthy subjects when initially given as a low dose or after repeated dosing. The authors noted that additive effects with alcohol were most pronounced in patients who used sedating antidepressants. Newer antidepressants have a reduced impact on driving skills. The authors stressed that many more patient studies are needed however to determine which antidepressant treatments have the least impact on driving performance.

Orriols et al (2009) reviewed a number of studies on prescription drug and driving. The categories discussed included antidepressants, lithium, opioids, H1 antihistamines, drugs for diabetes treatment, cardiovascular disease drugs, carbamates, and non-steroidal anti-inflammatory drugs (NSAIDs). They concluded from this review 'that the risk of motor-vehicle crashes related to benzodiazepines has been amply studied and demonstrated.' However, results for other medicinal drugs remain controversial. The review highlighted several fields where more epidemiological data are needed: 1. from larger studies investigating the individual and combined role of substances in the risk of road traffic crashes; 2. compare the differential effect of the older generations of medicinal drugs versus newer ones to adapt patient care; 3. the impact on crash risk of dose changes, beginning or end of treatment. The authors also suggested that some non-psychoactive medicinal drugs may alter driving abilities due to their action on physiological functions. The authors concluded that the impact of these medicinal drugs on road traffic crash risk has been insufficiently assessed in existing epidemiological studies. They recommended that future studies should be designed to assess the relative roles of disease and medication in the risk of road traffic crashes. Future research should also attempt to quantify the relative risks to FTD posed by a) a medical condition and b) the medicinal drugs used to treat that condition.

7.6 Hearing

The DVLA allows Group 1 drivers to drive with profound deafness without the need to inform DVLA. (DVLA, 2021). Group 2 drivers with deafness must be assessed but may not need to inform DVLA if they are able to communicate in an emergency through other means.

The literature search identified 232 papers on hearing loss and driving, of these Endnote software identified six systematic reviews. After screening no papers met the inclusion criteria for data extraction.

In the Monash review of hearing loss only four studies met the inclusion criteria. The quality of these studies was described as good or fair and all contained robust statistical analysis comparing MVC risk for affected drivers with that of the general population of drivers. The review authors concluded that hearing loss has no effect on MVC risk and there is no scientific evidence to support the inclusion of hearing loss in medical standards for FTD.

7.7 Mental and psychiatric disorders

Mental and psychiatric disorders encompass a wide-range of conditions which may affect FTD including anxiety, depression, schizophrenia, behavioural and personality disorders. Previous reviews suggest that drivers with mental or psychiatric disorders are at a higher risk of crash causation and other adverse driving outcomes than the general population (e.g. Hill et al., 2017).

The literature search identified 1553 papers on psychiatric or mental disorders and driving, of these Endnote software identified 13 systematic reviews. After screening, 10 reviews met the inclusion criteria for data extraction. There was overlap with the prescription drugs and young driver categories (described later in the report), and so some papers from this search are included in the summaries for those areas, which left three articles in this section:

Biçaksiz et al (2016) investigated the relationship between impulsivity and driver behaviours, offenses and road traffic accidents through the lenses of characterological perspective. Impulsivity is one of the most widely used constructs in psychology to explain especially maladaptive behaviour (De Wit, 2009). As the authors outlined, driving is probably one of the most widely studied contexts where impulsivity and/or impulsiveness can be expressed and/or experienced because of its self-paced nature (i.e., a driver usually decides himself/herself how to act and/or behave in traffic). The vast majority of the studies reported significant relationships between impulsivity and the driving outcomes. It was suggested that a new definition of impulsivity be made for the driving context, which would support future findings.

Akbari et al (2019) reviewed and performed a meta-analysis on the literature to determine the relationships risky driving behaviours have with the major personality factors, sensation seeking and driving anger. The meta-analysis indicated that the relationship risky driving behaviours have with ‘agreeableness’ was negative, for neuroticism, sensation seeking, and driving anger there were positive relationships. In contrast, risky driving behaviours were not significantly related to extraversion, conscientiousness, or openness. The finding of a negative relationship with agreeableness has been supported by previous studies, which have demonstrated that risky driving behaviour can be predicted by agreeableness. The authors concluded that more attention should be paid to the importance of traffic psychology in order to reduce and control risky driving behaviours, and that an additional prospective study with a larger sample size is warranted to investigate these risky driving behaviours in the presence of personality dimensions.

Kersten et al (2020) examined driving in people with autism. However, this review focussed on the driver experience and community mobility. The authors suggested that 'autistic adults face decreased community participation for employment, education, and social activities plus barriers to driving and transportation. However, little is known about their experiences of moving around community environments.' The searches for this report did not find any other research on autism and driving and as a result this might present an area for further research.

The Monash review on psychiatric disorders identified 24 studies for inclusion, but only four were rated as good quality. Two of these studies reported an increased crash risk among drivers with depression. Auden et al (2018) found a 34% increased risk of MVC among drivers with depression compared to the general population. Foley et al (1995) studied drivers aged 65 and over and reported a 50% increased risk of MVC in those with depression than those without. Dow et al (2013) reported a 32% increased risk of MVC among drivers with a psychiatric disorder. Orriols et al (2014) found that personality disorder was associated with being responsible for causing a MVC. The review authors concluded that there is limited research evidence on MVC risk and psychiatric disorders, and considerable heterogeneity between studies. Thus, although there appears to be an increased risk of MVC it is not possible to quantify the magnitude of the risk either generally or by specific diagnosis. The authors recommended that future research should include 'objective assessments of psychiatric disorder and MVC risk considering measurement of exposure as a confound, identification of risk factors for MVC among those with psychiatric disorder, delineation of the role of treatment and consideration of impacts of long-term psychiatric disorders and its' treatments on on-road driving performance.' They further recommended a consensus-based approach to reassessing the recommendations of FTD guidelines for psychiatric disorders.

7.8 Musculoskeletal disorders

Musculoskeletal conditions include rheumatoid arthritis, osteoarthritis, osteoporosis, and bone fractures. The DVLA guide for medical professionals does not cover these conditions. However these often debilitating conditions can affect a person's mobility and function and ability to safely drive a motor vehicle.

The literature search identified 341 papers on musculoskeletal disorders and driving, of these Endnote software identified 20 systematic reviews. After screening, three reviews met the inclusion criteria for data extraction. Two reviews focussed on arthritis or rheumatoid arthritis and another on total knee or hip arthroplasty. No reviews have assessed crash risk.

Zhou et al (2018) reviewed the driving performance and safety in people with rheumatoid arthritis (RA). Based on weighted means, of the total RA patients studied 13% were involved in motor vehicle crashes (MVCs), 26% experienced difficulties with driving, 34% leveraged assistance or modifications to drive, and 26% were unable to drive. In at least one study, patients were involved in fewer MVCs than their age-matched controls (23% vs.35%). Another study employing an independent driving assessment found that 19% (n=37) of RA patients were not fit to drive. The review authors concluded that 'there is a scarcity of data that quantitatively relates RA to driving performance and or related safety outcomes…[and that] recognizing significant variability among individual reports, available data suggests that driving difficulties and the subsequent use of modifications are prevalent in those with RA.'

Cammarata et al (2020) reviewed arthritis research, the predominant diagnosis being rheumatoid arthritis. The most common facilitators for driving in this population were vehicle adaptations (e.g. supplemental mirrors, seat cushions). Barriers included a lack of knowledge among clinicians to address behind-the-wheel concerns and non-use/abandonment of such

adaptions. The authors concluded that the results highlight clinical and research opportunities to support drivers with arthritis, including determining the best strategies to promote safety and comfort when behind-the-wheel which 'should be a priority in both the care and rehabilitation of those living with arthritis.'

Na et al (2020) reviewed total knee arthroplasty (TKA) or total hip arthroplasty (THA), to examine patient characteristics and clinical determinants that may influence return to driving status. Twenty-three studies were included. Most patients achieved or exceeded preoperative response times between 1 and 8 weeks following a TKA and 2 days to 8 weeks following a THA, and/or self-reported return to driving between 1 week and 6 months. Influences on return to driving time included laterality and pain. The primary finding of this systematic review was that most patients returned to driving a car at about 2 to 4 weeks after a right-sided TKA or THA in predominately right-sided driving countries, which was consistent with previous studies. The authors concluded that recommendations for return to driving a car after a TKA and THA are difficult because they must optimize safety and the patient's quality of life. Current studies use surrogate measures, including response times using driving simulators or self-reported questionnaires to assess return to driving. The authors recommended that future studies should consider pain levels, especially since narcotic use for pain management while driving can jeopardize societal and patient's safety, and to determine the influence of pain on driving to determine adequate pain management and return to driving. Gender differences were examined in several of the reviewed studies but results were variable. The authors further recommended that future studies of large sample size should examine self-perceived readiness to drive, objective data, and specific details on surgical and clinical management.

7.9 Neurological disorders

7.9.1 Attention Deficit Hyperactivity Disorder (ADHD)

The definitions of Attention Deficit Hyperactivity Disorder (ADHD) are based on maladaptively high levels of impulsivity, hyperactivity and inattention (NICE, 2009). ADHD is usually associated with children and young people, however it can extend into adulthood. ADHD changes with age. It is thought that some children no longer have impairments; however, the majority, around 65%, retain some impairments in adulthood (ADHD UK, 2022). Patients with ADHD are more prone to physical injuries, including motor vehicle accidents, fractures and brain injuries (Man, et al. 2017). Prevalence figures for the UK are difficult to ascertain as many cases are undiagnosed. The global prevalence of ADHD is estimated as between 2% and 7%.

The literature search identified 31 papers on ADHD and driving, of these, Endnote software identified 16 systematic reviews. Screening found that most were not systematic reviews or were not specifically about driving. After screening, two reviews met the inclusion criteria for data extraction, one overlapped with the literature on young drivers, the other overlapped with medicinal drug use:

A review by Bruce et al (2014), focussed on non-pharmacological behavioural interventions for young drivers with ADHD. The review had two aims: (1) to systematically review the effectiveness of behavioural interventions to improve driving outcomes for this population, and (2) to identify studies detailing behavioural interventions that could be used to improve driving skills. For the first aim, while two studies reported training led to significant improvements in driver skills, methodological problems limited the validity of one study. Eleven studies were reviewed in relation to the second aim, describing nine interventions. Of these, situation awareness training, such as commentary driving, show particular promise. The authors concluded that, to date, most research has focused on examining brain correlates and driving

behaviours related to contributing factors for fatal motor vehicle crashes. In the identified studies, there were primarily two areas of investigation pursued; driving impairment and distraction in driving. Impairment studies primarily explored the areas of drowsy/fatigued driving or alcohol-impaired driving. Studies of distracted driving primarily focused on cognitive load and auditory and visual distractors. As such, there remains a lack of research designed to understand underlying brain mechanisms that might otherwise facilitate greater understanding of individual variability of normative and risky driving behaviour within the young driving population.

Boland et al (2020) reviewed 40 articles on medicine treatment for ADHD. The majority suggested 'a robust protective effect of ADHD medication treatment on mood disorders, suicidality, criminality, substance use disorders, accidents and injuries, traumatic brain injuries, motor vehicle crashes, and educational outcomes. Similarly, the meta-analyses demonstrated a protective effect of medication treatment on academic outcomes, accidents and injuries, and mood disorders.' The authors concluded that these findings also support the critical need to develop innovative methods to improve adherence to medications in ADHD. In terms of future research, the overwhelming majority of the pharmacological treatments for ADHD consisted of stimulants and none of the available studies reported findings on non-stimulants alone.

7.9.2 Brain injury

There are several types of brain injury (e.g. aneurisms, brain tumours, concussion, encephalitis, and traumatic brain injury (TBI)). The most common type is TBI, with a worldwide incidence of over 50 million cases per year (Maas et al, 2017). In the UK, NICE has estimated that 1.4 million people annually attend accident and emergency departments with a head or brain injury (NICE, 2014). Functional and cognitive sequelae after TBI can continue for years post injury. The US Centres for Disease Control and Prevention have estimated that due to the 2% of the US population are living with long-term disability following TBI (CDCP, 1999).

TBI is associated with a wide range of impairments which may impair driving fitness. These include cognitive impairments, fatigue, visuospatial perception, insight, judgement, attention, comprehension, reaction time, memory, sensation, muscle power, coordination, and vision. TBI has also been identified as a risk factor for other conditions which can negatively affect driving, such as dementia, depression, seizures, stroke, Parkinson's disease, and post-traumatic stress disorder (PTSD).

The literature search identified 1972 papers on brain injury and driving, of these, Endnote software identified 22 systematic reviews. After screening, seven reviews met the inclusion criteria for data extraction:

Baker et al (2015) carried out a systematic review of the methods and assessments used after mild traumatic brain injury. The aim was to identify what methods and assessments are or could be used to determine FTD for this population. Seven articles were included in the review. Self-reported questionnaires, non-standardised assessments, questionnaires completed by next-of-kin, and simulator tests were the primary methods used to determine FTD. The authors concluded that although a variety of methods and assessments are currently used, there is little research evidence to suggest when individuals are able to return to driving after mild traumatic brain injury. They recommended that research is urgently needed to determine a consistent and standardised approach to assessing FTD following mild traumatic brain injury.

Brenner et al (2008) carried out a review of driving, aging, and traumatic brain injury. The authors concluded that individuals aging with TBI may be at increased risk for driving-related problems, and that areas for clinical consideration include seizures, sleepiness and fatigue, vision, cognition, driving assessment, and caregiver involvement. They recommended that further research is needed on post-acute driving assessment and rehabilitation.

Egeto et al (2019) carried out a systematic review and meta-analysis on the association between driving ability and performance on neuropsychological tests after moderate to severe TBI. The rationale for the study was that driving requires the coordination of multiple cognitive, perceptual, and psychomotor functions, so neuropsychological testing may offer an estimate of driving ability. Eleven studies were included in the meta-analysis. Results showed that . Executive functions had the largest effect size, followed by verbal memory, processing speed/attention, and visual memory. Of the individual tests, Useful Field of Vision (UFOV) divided attention, Trail Making Test B, and UFOV selective attention had the largest effects. Years post injury and age emerged as significant predictors of effect sizes. The authors concluded that the results provide preliminary evidence of associations between neuropsychological test performance and driving ability after moderate to severe TBI and highlight moderating effects of demographic and clinical factors.

Tamietto et al (2006) carried out a review of the literature on driving after TBI and implications for rehabilitation and future research. The rationale for the study was that prior studies are highly inconsistent in the choice of measures recommended for predicting driving fitness from different pre-driving measures, and the authors wished to identify the reasons for this. The authors state that the discrepant results reflect investigative choices which differ in five aspects: (1) the type of predictors used as pre-driving screening; (2) the type of measures considered as the criterion for the determination of FTD after TBI; (3) the severity of the TBI in the sample of patients studied; (4) the extent of the neural structures damaged by TBI and the overlap of these areas with those involved in driving tasks; (5) the length of the follow-up considered. The authors concluded that encouraging findings come from recent studies that combined together medical, psychosocial, and personality measures, which improved the explanatory power of the predictors used.

Ortoleve et al (2012) carried out a systematic review of predictors for the ability to return to driving after traumatic brain injury. Seven articles were included in the review, although five of these were of limited quality. The included studies mentioned 38 predictors of driving after TBI, the most frequently mentioned were "selective attention" and "divided attention" in 4/7 studies, and "executive functions" and "processing speed". No association with driving was observed for 19 candidate predictors. Eighteen candidate predictors from 3 domains were associated with driving capacity: patient and trauma characteristics, neuropsychological assessments, and general assessments. The results of associations were contradictory for all but one: time between trauma and driving evaluation. The authors concluded that there is no sound basis at present for predicting driving capacity after traumatic brain injury because most studies have methodological limitations.

Chee et al (2018) carried out a systematic review and meta analysis of the risk of MVC or driving impairment after traumatic brain injury. Eight studies were included in the review, but only six contained a measure of on-road driving. Four of the six studies reported on MVC risk, and analysis of pooled data for these studies showed no significant difference in the risk of MVC between drivers with TBI and without TBI. Two of the six studies evaluated on-road test performance of participants with TBI compared with age-matched drivers without TBI. Both studies reported lower overall road test scores in the TBI group, but only one of the studies found that the driving test failure rate was significantly higher in the TBI group than the non-TBI

group. The review authors identified methodological limitations among the included studies and were thus unable to find strong evidence regarding the relationship between TBI and crash risk. They recommended further research to examine MVC risk with respect to TBI severity and time post-injury, with carefully defined injury severity and objective measures of MVC risk. This review also forms part of the Monash report.

7.9.3 Dementia or Alzheimer's Disease

According to the Alzheimer's Society, there are currently nearly 36 million people with dementia worldwide, but as many as 28 million of those living with dementia do not have a diagnosis. In the UK it has been estimated that there were over 850,000 in 2019, with a predicted rise to 1 million by 2025 (Alzheimer's Society, 2022). True figures are likely to be higher due to sub-optimal rates of diagnosis, especially since the Covid pandemic which has delayed assessments. Prior to a diagnosis of dementia, many people will be living with some form of cognitive impairment which can also negatively affect driving.

Alzheimer's disease (AD) is a progressive, degenerative brain disorder characterized by impairments in multiple cognitive functions. The earliest cognitive symptoms include difficulties in recent memory, word finding, orientation, and concentration. In later stages cognitive changes include slowed rates of information processing, attentional deficits, disturbances in executive functions, impairments in language, perception, and praxis. The impairments in cognitive functioning increasingly interfere with social and occupational functioning, including the driving abilities of affected patients (Dobbs, 2005). Because of the progressive nature of the disease, at some point in the course of their illness, all individuals with a progressive dementia will become incapable of driving safely and will eventually stop driving. However, many patients continue to drive after the onset of their illness. Appropriate and timely advice from health professionals is therefore crucial for the safety of sufferers and other road users.

The literature search identified 624 papers on dementia or Alzheimer's disease and driving, of these Endnote software identified 32 systematic reviews. After screening, 26 reviews met the inclusion criteria for data extraction. Several reviews examined cognitive and/or on-road tests for assessing FTD among patients with dementia or mild cognitive impairment. Others examined interventions to assist older drivers with dementia. Other reviews covered the topic of driving cessation. A consistent message from the evidence is that there is a need for tools with sufficient validity to help clinicians assess driving ability among patients with dementia, particularly in the early stages. There were too many studies to summarise in this report, so a selection are presented below:

Hird et al (2016) carried out a systematic review and meta-analysis of on-road simulator and cognitive driving assessment in Alzheimer's disease (AD) and mild cognitive impairment (MCI). Thirty-two articles were included in the review. Driving outcomes included on-road test scores, pass/fail classifications, errors; caregiver reports; real world crash involvement; and driving simulator collisions/risky behaviour. The authors found that executive function, attention, visuospatial function, and global cognition emerged as significant predictors of driving performance. Patients with very mild AD or mild AD were more likely to fail an on-road test than healthy control drivers, with failure rates of 13.6%, 33.3% and 1.6%, respectively. The authors concluded that the driving ability of patients with MCI and AD appears to be related to degree of cognitive impairment. There were inconsistent cognitive predictors and reported driving outcomes in MCI and AD patients across studies. They recommend that future large-scale studies should investigate the driving performance and associated neural networks of subgroups of AD (very mild, mild, moderate) and MCI (amnestic, non-amnestic, single-domain, multiple-domain).

Toepper and Falkenstein (2019) carried out a systematic review into driving fitness in different forms of dementia including Alzheimer's Disease and non-Alzheimer dementias, and Parkinson's disease dementia. The evidence reviewed suggests that FTD is severely impaired in moderate and severe dementia, irrespective of the type of dementia. However, in the milder disease stages, FTD appears to be more severely impaired in non-Alzheimer dementias as these syndromes are associated with both driving-relevant cognitive risk factors and noncognitive risk factors, such as behavioural or motor symptoms.

A rigorous systematic review and meta analysis of the risk of motor vehicle collision or driving impairment with dementia was carried out by Chee et al (2017), and this review is also reported in the Monash report (2021). Six studies were included in the review: two investigated MVC risk, and four investigated on-road test outcome (pass/fail). For those which investigated MVC risk, one study reported a four-times increase in risk of MVCs per 1000 miles driven/week in the three years prior to the study. The second study reported no significant increase in MVCs in the same time period. Meta analysis of the four studies which investigated on-road test outcomes showed that drivers with dementia were 10 times more likely to fail an on-road driving assessment than healthy controls. The authors concluded that there is a lack of data regarding MVCs but that the current evidence shows that even mild stages of dementia are associated with a substantially higher risk of failing an on-road driving assessment than matched controls They recommended that an individual with a dementia diagnosis is not fit to hold an unconditional driving licence and a 'conditional licence may be considered by the driver licensing authority subject to at least annual review, which takes into account: 1) the nature of the driving task; 2) information provided by the treating doctor regarding the level of functional impairment and the likely impact on driving ability; and 3) the results of a practical driver assessment if required.'

A Cochrane review by Martin et al (2013) examined driving assessment for maintaining mobility and safety in drivers with dementia. The review objectives were a) to assess whether driving assessment facilitates continued driving in people with dementia, and b) to assess whether driving assessment reduces accidents in people with dementia. They sought randomised controlled trials prospectively evaluating drivers with dementia for outcomes such as transport mobility, driving cessation or motor vehicle accidents following driving assessment, but found no studies which met these criteria. The authors concluded that in 'an area with considerable public health impact for drivers with dementia and other road users, the available literature fails to demonstrate the benefit of driver assessment for either preserving transport mobility or reducing motor vehicle accidents'. They recommended that driving legislation and recommendations from medical practitioners requires further research in order to provide the best outcomes for both drivers with dementia and the general public.

Bellagamba et al (2020) carried out a systematic review of standardized on-road tests assessing fitness to-drive in people with cognitive impairments. The rationale for the review was that the on-road assessment is the gold standard because of its ecological validity, but existing instruments are heterogeneous and little is known about their psychometric properties. The objective of the review was to identify existing on-road assessment instruments and extract data on psychometric properties and usability in clinical settings. Eighteen recent studies were included in the review, between them they investigated 12 different on-road evaluation instruments. Study participants had a broad variety of cognitive disorders, were aged between 48 and 80 years, and two thirds were male. Most instruments showed reasonable psychometric values for internal consistency, criterion validity, and reliability. However, because few studies evaluated each instrument the level of evidence was too poor to recommend any of them. The

authors concluded that despite the social and health consequences of decisions taken using these instruments, little is known about the value of a single evaluation and the ability of instruments to identify expected changes. They further concluded that 'none of the identified on-road evaluation instruments seem currently adapted for clinical settings targeting rehabilitation and occupational priorities rather than road security alone'. The authors recommended that future research be carried out to determine the relevance of conducting a driving assessment in an ecological environment and that this association should be explored in people with cognitive impairments. There is also a need for studies to evaluate the responsiveness of evaluation instruments to known changes in health conditions, and to develop methods to distinguish driving lapses and errors due to health conditions from those due to other causes. A possible solution could be to develop instruments that rely on at least three separate driving phases: evaluation, intervention, and re-evaluation. The authors also stressed the importance of involving occupational therapists during the on-road assessment.

Bennett et al (2016) carried out a systematic review of cognitive tests to determine FTD in dementia. The review rationale was that although all individuals with dementia will eventually need to stop driving, most can continue to drive safely early in the disease. FTD needs to be monitored, and the use of cognitive testing to determine driver safety has been suggested. The review objective was to examine the relationship between cognitive tests and driving to determine whether a cognitive assessment can be implemented as a tool to examine driver safety. Twenty-eight studies were included. Results showed inconsistent findings with some studies showing a relationship between cognitive testing and driving performance for individuals with dementia, whereas others did not. Results relating to individual cognitive tests and measures confined to a single cognitive domain were not consistently associated with driving performance, but composite batteries were much better at predicting driving performance. However, the authors concluded that these composite batteries are not clinically usable because they lack the ability to discriminate sufficiently between safe and unsafe drivers. They recommended that future research is needed to develop a reliable, valid composite battery that can correctly determine driver safety in individuals with dementia.

In 2020 the DfT funded a multidisciplinary project focused on older, vulnerable drivers who have recently been involved in a road traffic accident and may be demonstrating signs of cognitive impairment without having dementia. Entitled 'Data-driven assessment of driving behaviour in cognitive vulnerable elderly' the project uses police data, machine learning, spatial navigation and other cognitive tests to establish cognitive and driving profiles of drivers at high risk of unsafe driving and being involved in collisions. This project is being carried out by the University of East Anglia with a completion date of 31st December 2022.

7.9.4 Epilepsy and/or seizures

According to Epilepsy Research UK (2022) there are over 600,000 people in the UK with a known diagnosis of epilepsy, equating to one in 103 people. Epilepsy can be caused by a brain injury, brain tumour, or stroke. Epilepsy may also be a result of a neurodegenerative disease such as dementia. In some cases, epilepsy is a genetic condition.

The DVLA's definition of epilepsy for licensing purposes encompasses all seizure types, including major, minor and auras (DVLA, 2021). The licensing rules are different depending on whether there is a diagnosis of epilepsy or multiple unprovoked seizures or if there has been a single unprovoked epileptic seizure/isolated seizure. For both, the driving rules differ for Group 1 and Group 2 drivers. The annual risk of seizure is considered to be 2% or lower for bus and lorry drivers (DVLA, 2021).

For a diagnosis of epilepsy/multiple unprovoked seizures Group 1 drivers must not drive and must notify DVLA. Driving must cease for 12 months from the date of the most recent seizure, unless the seizure meets legal criteria to be considered as a permitted seizure. Group 2 drivers must not drive and must notify DVLA. The person with epilepsy must remain seizure-free for 10 years (without epilepsy medication) before licensing may be considered.

For a first or single unprovoked seizure Group 1 drivers must not drive and must notify DVLA. Driving must cease 6 months from the date of the seizure, or for 12 months if there is an underlying causative factor that may increase risk. Group 2 drivers must not drive and must notify DVLA. Driving must cease 5 years from the date of the seizure.

The literature search identified 459 papers on seizures or epilepsy and driving, of these Endnote software identified 13 systematic reviews. After screening, seven reviews met the inclusion criteria for data extraction:

Bonnett, et al (2011) carried out a systematic review into seizure recurrence after antiepileptic drug withdrawal and the implications for driving. This review formed part of the Medical Research Council Antiepileptic Drug Withdrawal Study. The rationale for the study was that at the time, in the UK, patients with epilepsy in remission who withdraw antiepileptic drug (AED) treatment, were advised not to drive during withdrawal and for 6 months thereafter, assuming the risk of recurrence in the next 12 months is below 20%. This was out of step with EU regulations which recommended returning to driving 3 months after restarting treatment. Results of the review found that immediately following treatment withdrawal, the recurrence risk in the next 12 months was 30% and at 3 months after withdrawal was 15% . At 3 months following the recommencement of treatment following a seizure recurrence, the risk of a seizure in the next 12 months was 26%, at 6 months 18%, and at 12 months 17%. The authors concluded that for those restarting treatment after a seizure recurrence, current UK guidance may be too conservative but the new EU guidance too liberal.

Thomas et al (2010) carried out a systematic review into awake seizures after pure sleep-related epilepsy. The objective of the review was to determine the risk of awake seizures in pure sleep-related epilepsy. Six studies were included in the review, but each one had a different definition of pure sleep-related epilepsy. Using the largest prospective study, the authors calculated ‘next year's awake seizure chance (treated with antiepileptic medication)’, which was maximal in the second year: 5.7% (95% CI 3.0 to 10.4%). The review authors concluded that there is a lack of evidence to support present UK licensing law, stating that ‘current rulings would be difficult to defend if legally challenged. The law may be penalizing people with pure sleep-related epilepsy without increased risk of awake seizures, while failing to identify subgroups at unacceptable risk of an awake seizure at the wheel’.

Naik et al (2015) carried out a systematic review of the evidence regarding MVC risk for drivers with and without epilepsy. The review objective was to understand the magnitude of the risk that drivers with epilepsy (DWE) contribute to motor vehicle accidents (MVCs) compared to other drivers. Seven studies were included in the review. Two studies used patient report to ascertain MVC rates, these studies reported a trend toward a decreased rate of overall MVC rates for DWE when compared with the general population. Three studies used independent measures to ascertain MVC rates, these studies reported a trend toward or an increased risk of MVC rates for DWE when compared with the general population. One study showed that, compared to fatal crashes with DWE, fatal crashes were 26 times more likely to occur because of other medical conditions and 156 times more likely to occur because of alcohol abuse. The final study reported that MVCs due to seizures in DWE occurred in one out of every 2800 MVCs. The review authors concluded that he evidence for the difference in MVC rates in DWE compared to the general population is inconsistent, due to important methodological differences

across the studies, and no conclusions were possible. They recommended that future research should be performed using objective measures rather than self-reporting of MVCs by DWE and "miles driven" as the denominator to calculate MVC rates.

Xu et al (2019a) carried out a systematic review on the prevalence of driving and traffic accidents among people with seizures. The review objectives were to determine the prevalence of driving or holding a driver's license among people with seizures, the prevalence of traffic accidents among those who drive, and factors that may explain heterogeneity in these point estimates. Sixty-seven studies were included in the review but across the studies there was a wide range in the prevalence of driving (3-90%) and holding a driver's license (8-98%). There was also considerable heterogeneity between studies related to definitions, design, and population differences. The review authors concluded that there is considerable variation in the prevalence of driving after a diagnosis of epilepsy and in reported motor vehicle accidents. They recommended further research to better understand the impact of epilepsy, and epilepsy surgery, on driving and road safety, especially where driving continues in violation of restrictions.

Xu et al (2019b) published a similar further systematic review and meta-analysis among people with seizures. The objective was to systematically summarize factors associated with driving, holding a driver's license, and traffic accidents among people with seizures. Data from 18 studies were included in the meta-analysis. The authors concluded that stable multivariate models to predict driving or traffic accidents among people with seizures have not yet been developed, an that current evidence shows that the likelihood of driving is associated with demographic and epilepsy-related factors, while the risk of traffic accidents is associated with seizure frequency.

Asadi-Pooya et al (2020) carried out a systematic review on psychogenic nonepileptic seizures (PNES) and driving, as part of a wider study for the International League Against Epilepsy (ILAE) Task Force on psychogenic nonepileptic seizures. The review objective was to summarise the literature about "driving and PNES. Eight studies were included in the review but these failed to provide a firm evidence base for PNES-related driving regulations. The second phase of the study was to collect international expert opinion on PNES and driving. The results were that most experts held the view that decisions about driving privileges should consider individual patient and PNES characteristics and take account of whether permits are sought for private or commercial driving. Most felt that those with active PNES should not be allowed to drive unless certain criteria were met and that PNES should be thought of as "active" if the last psychogenic seizure had occurred within 6 months. The authors recommended that future research is needed to determine the risk of accidents in drivers with PNES.

In the Monash review of MVC risk associated with seizures or epilepsy, 23 studies were included, but only 16 provided direct evidence on the MVC risk associated with epilepsy. Of these 11 were rated as good or fair quality. Four of the six rated ‘good’ reported an increased MVC risk for patients with seizures or epilepsy. Two studies reported no difference in crash risk between seizure or epilepsy patients compared to the general population. The authors concluded that the available evidence on MVC risk associated with seizures or epilepsy is mixed and not of high quality. They recommend that a large-scale population-based controlled study across multiple centres is needed to achieve a sufficient sample size to make firm conclusions. This review has now been published as Koppel et al (2021).

7.9.5 Multiple Sclerosis (MS)

Multiple sclerosis (MS) is a chronic condition which affects the central nervous system. MS can affect vision, balance and cognitive processes. The MS society estimates that there are over 130,000 people with MS in the UK, that nearly 7,000 people are newly diagnosed each year, and approximately one in every 500 people in the UK has MS (MS Society, 2022).

The literature search identified 28 papers on MS and driving, of these, Endnote software identified two systematic reviews, both of which met the inclusion criteria for data extraction:

Krasniuk et al (2019 carried out a systematic review on clinical determinants of FTD in persons with multiple sclerosis. They concluded that there is currently insufficient evidence for predicting driving performance in driving simulator studies, there is some evidence for predicting FTD in on-road studies. The best available evidence suggests that the Stroke Driver Screening Assessment and Useful Field of View test probably predict FTD in adults with MS. They identified a need for high quality studies with large prospective samples of adults with and without MS in order to compare predictors of FTD.

The second review by Marino et al (2013) studied interventions to evaluate FTD among people with chronic conditions. They included 27 studies which covered a range of conditions including Parkinson's disease, but which only included one patient with MS. The authors found no evidence that clinical and neuropsychological screening tests would lead to a reduction in motor vehicle crashes involving chronic disabled drivers. They recommended that screening tests be developed with proven validity for identifying high-risk drivers so that physicians can provide guidance both to their patients, and to medical licensing advisory boards.

7.9.6 Parkinson's disease

Parkinson's disease (PD) is a chronic, progressive neurodegenerative condition resulting from the loss of the dopamine-containing cells of the substantia nigra (NICE, 2022). PD is most common in elderly people, with a prevalence of 1–2% in people older than 65 years of age. A report by Parkinson's UK found that in 2015 there were approximately 137,000 people in the UK living with PD, however they warned this may be an underestimate due to PD being underdiagnosed in older age-groups with symptoms being put down to normal aging, or masked by multiple other health conditions (Parkinson's UK, 2018]). The prevalence rate was 286.5 per 100,000 person years, and the incidence rate was 33.4 per 100,000 person years, and each year there are about 17,300 new diagnoses of PD in people aged 45 years and above. The complications of PD include motor complications (often related to anti-parkinsonian medication) such as immobility, slowness, communication difficulties, motor fluctuations, dyskinesia, and freezing of gait; and non-motor complications, such as depression, anxiety, impulse control disorders, psychotic symptoms, dementia, sleep disturbance, autonomic dysfunction, falls, and pain (NICE, 2022). A driver diagnosed with PD must notify DVLA. DVLA rules are the same for both Group 1 and Group 2 drivers who may drive as long as safe vehicle control is maintained at all times. However, if the individual's condition is disabling and/or there is clinically significant variability in motor function, the licence will be refused or revoked (DVLA, 2021).

The literature search identified 239 papers on Parkinson's disease and driving, of these Endnote software identified 11 systematic reviews. After screening, four reviews met the inclusion criteria for data extraction but two have already been described (one of these papers was the Marino review described in 7.9.5, the other is the Toepper and Falkenstein review of different forms of dementia including PD described in 7.9.3).

Devos et al (2015) carried out a systematic review of on-road driving studies with a view to creating an evidence-base framework for driving rehabilitation in Parkinson's disease. They reviewed 27 studies, 26 of which were prospective, participants were in the mild to moderate stages of PD. The found that drivers with PD were more likely to fail a driving assessment compared to age and gender matched controls. Compared with controls, drivers with PD experienced difficulties on all levels of driving skill. However, drivers with PD demonstrated compensation strategies indicating they were aware of their diminished driving skills. The authors concluded that a combination of visual, cognitive, and motor deficits underlie impaired on-road driving performance in PD and that driving rehabilitation strategies for individuals with PD should include training of operational and tactical driving skills, and training in visual, cognitive, and motor skills.

Thompson et al (2018) carried out a systematic review of driving impairment and crash risk in Parkinson disease with the aim of providing a best-evidence base for guiding driving decisions in Parkinson disease. A total of 5410 participants: 1955 with PD and 3455 healthy controls. They found that the odds of an on-the-road test failure were six times higher for PD patients with poorer overall driving ratings also observed. However, self-reported real-life crash involvement did not differ between people with PD and controls. The authors concluded that their findings provide persuasive evidence for substantive driving impairment in PD, but that licensing decisions should not be based on self-reported crash data alone and should include objective measures of crash involvement.

7.9.7 Stroke, CVA or TIA

The World Health Organisation (2022) states that annually 15 million people worldwide suffer a stroke. According to the Stroke Association (2022) the annual incidence of strokes in the UK is about 100,000, and there are 1.3 million stroke survivors in the UK. With the aging UK population and improvements in treatment, the number of stroke survivors is estimated to rise by 60% between 2015 and 2035 (King et al, 2020). The prevalence rate for stroke in the UK is currently around 1% for 45-64 year olds, rising to 2% for 75-84 year olds and 2.5% for those aged 85 and over. Although stroke is associated with cognitive, visual and physical impairments, for Group 1 drivers DVLA rules state that driving may resume after one month if there has been satisfactory clinical recovery and DVLA does not need to be notified unless there is residual neurological deficit one month after the episode, such as visual field defects, cognitive defects, or impaired limb function (DVLA, 2021). Group 2 drivers must not drive and must notify DVLA, the licence will be refused or revoked for one year following a stroke or TIA.

The literature search identified 698 papers on stroke, CVA or TIA and driving, of these Endnote software identified 24 systematic reviews. After screening, nine reviews met the inclusion criteria for data extraction.

In general most papers concluded that the available evidence does not show a clear increase in crash risk after stroke or TIA. Some stroke patients are at risk of a MVC but others are not, depending on stroke severity and stage of rehabilitation. Most authors recommend an individualised approach to licensing decisions, using standardised tests to predict FTD with an on-road or off-road test as appropriate. Recommendations for future research tended to be calls for more robust controlled studies of crash risk after stroke, and identification of reliable predictive tests to assess FTD.

Rapoport et al (2019) carried out a systematic review of the risk of MVC after stroke or transient ischemic attack. Eight studies specifically investigated MVC risk were included in the review. However, the authors reported a lack of relevant studies and a lack of consistent adjustment for

potential confounding factors (e.g. age, gender, comorbidities, driving exposure). No studies investigated the impact of stroke/TIA on on-road driving test outcome, and only one study reported an increased risk of MVC associated with stroke/TIA, but this was based on self-report, not externally validated data. The authors concluded that the evidence does not support a robust increase in risk of MVCs for drivers who have experienced stroke or TIAs. They recommended that a driver licensing authority may consider a return to driving after stroke or TIA 'on an unconditional licence, after at least four weeks, taking into account: 1) the nature of the driving task; 2) information provided by an appropriate specialist regarding any functional impairments that are likely to impact on driving ability; and 3) the results of a practical driver assessment if required.' This review also forms the Stroke chapter in the Monash report.

Linkewich et al (2018) carried out a systematic review of the crash risk following a stroke or TIA. Twelve articles were included. They concluded that the evidence does not support a clear connection between stroke and crash risk. They recommended that further research is needed to quantify MVC risk after stroke and to identify robust clinical predictors of risk, and that clinical decisions should be made after individualised assessments based on function and where appropriate include both on and off-road testing.

Only one systematic review explored FTD among commercial drivers after stroke. Rabadi et al (2010) carried out a review of the safety of driving a commercial motor vehicle after a stroke. They reported that the evidence shows that TIA patients are at increased risk for stroke, and that stroke patients are at increased risk for a MVC. The authors concluded that although no studies provide direct evidence that neurological assessments can predict crash risk among CMV drivers, there is evidence that some neuropsychological tests can identify on-road driving performance after stroke.

7.10 Respiratory disorders including COPD

The DVLA guidance for medical practitioners refers to disorders of respiratory function including asthma and COPD. Unusually, the driving rules are the same for both Group 1 and Group 2 drivers. For both groups, drivers may drive and need not notify DVLA unless complications are associated with cough syncope, disabling dizziness, fainting, or loss of consciousness. In these cases doctors should refer to requirements under 'Transient loss of consciousness' (DVLA, 2021).

The literature search identified 1414 papers on respiratory disorders including COPD and driving, of these, Endnote software identified 33 systematic reviews. After screening, nine reviews met the inclusion criteria for data extraction. However, all of these reviews were about sleep apnoea and there was complete overlap with reviews extracted under Sleep disorders below. Consequently we have not repeated them here. From the perspective of FTD it appears that respiratory disorders should be included in the broader topic of sleep disorders.

7.11 Sleep disorders

Sleep disorders include Obstructive Sleep Apnoea (OSA), excessive daytime sleepiness, narcolepsy, insomnia, and drowsiness. The DVLA states that drivers with excessive sleepiness with or without OSA must not drive (DVLA, 2021). It has been estimated that there are 1.5 million adults in the UK with OSA but up to 85% are undiagnosed and consequently remain untreated (British Lung Foundation, 2015). There is a lack of published data on the global prevalence of OSA, however it has been recently estimated that worldwide there approximately 1 billion adults with OSA (Benjafield, et al, 2019). OSA is more common among people who are male, middle aged, elderly, and over-weight. As well as the risk of excessive daytime

sleepiness, which is a counterindication for driving, OSA is associated with major neurocognitive and cardiovascular sequelae.

The literature search identified 2156 papers on sleep disorders and driving, of these Endnote software identified 78 systematic reviews. After screening, 26 reviews met the inclusion criteria for data extraction. Eight reviews included discussion on sleep apnoea or obstructive sleep apnoea, 10 reviews covered sleepiness and/or fatigue or drowsiness, including one review on the combined impact of drowsiness and distraction. The eight other articles overlapped with other conditions and are not included in this section. Seven reviews are summarised here:

Garbarino et al (2016) reviewed studies to quantify the proportion of road traffic injuries (RTIs) attributable to OSAs. The results showed that about 7% of road traffic injuries (RTIs) for a population of male drivers involved in MVAs are attributable to OSAs, and thus provides an initial figure to highlight the scale of the problem.

Ellen et al (2006), in a review of non-commercial drivers, found in the majority of studies of drivers with OSA, (23 of 27 studies and 18 of 19 studies with control groups) a statistically significant increased risk of crashes, with many of the studies finding a 2 to 3 times increased risk. Methodologic quality of the studies did not influence this relationship. For commercial drivers, only one of three studies found a weak association with increased crash rate. The evidence was mixed regarding whether the risk of crash involvement is proportional to the severity of the sleep apnoea, with about half of the studies finding a statistically significant increased risk with increased severity. Correlation with subjective daytime sleepiness and crash risk was also found in only half of the studies reviewed. Treatment of sleep apnoea was also found to consistently improve driver performance (including crashes) across all studies. The researchers recommended that clinicians educate their patients with sleep apnoea about the importance of treatment adherence for driving safety. This review also highlighted a number of research gaps in the literature, whereby future research could further delineate the relationship between sleep apnoea severity and daytime sleepiness and crashes. Future studies to determine whether other potential risk factors (e.g., body mass index, comorbid conditions, use of sedating medications) have an impact on crash risk in drivers with sleep apnoea were also recommended.

A review by Tregear et al, 2010 suggested the use of continuous positive airway pressure (CPAP) reduces crash risk in motor vehicle drivers with OSA. The authors concluded that individuals with OSA are ‘clearly at increased risk for crash’ and that the mean crash-rate ratio associated with OSA is likely to fall within the range of 1.21 to 4.89. They also identified the characteristics which may predict crash in drivers with OSA, including BMI; apnoea plus hypopnea index; oxygen saturation; and possibly daytime sleepiness.

Philip et al (2016) carried out a systematic review and meta-analysis on sleepiness at the wheel and traffic accidents. They found that sleepiness at the wheel was associated with an increased risk of motor vehicle accidents. A significant heterogeneity was however found between the individual risk estimates. Meta-regression found that an increasing frequency of participants reporting sleepiness at the wheel was associated with an increased risk of accidents ($P < 0.05$). The authors concluded that systematically looking for sleepiness at the wheel in patients suffering from sleep disorders should happen in order to predict accidental risk. Moradi et al (2019) further corroborated the findings, in a review spanning 14 studies from 1980-2016, they reported a significant association between crash involvement and drowsy driving. Bioulac et al (2017) also found a positive association between sleepiness and accidents and suggested that sleepiness at the wheel should be included in determining medical FTD.

Cai et al (2021) in a review incorporating 34 studies from 1995-2020 suggested that drivers were aware of sleepiness, and this was associated to physiological drowsiness and driving impairment, such that high levels of sleepiness significantly predicted crash events and lane deviations. Subjective sleepiness was more strongly correlated (i) with physiological drowsiness compared to driving outcomes; (ii) under simulated driving conditions compared to naturalistic drives; and (iii) when examined using the Karolinska sleepiness scale (KSS) compared to other measures. The authors concluded that this provided evidence that drivers are aware of drowsiness while driving, and stopping driving when feeling 'sleepy' may significantly reduce crash risk. They suggested that future research should examine whether subjective sleepiness predicts physiological drowsiness while driving using highly controlled high fidelity or naturalistic/track studies.

A review by Schreier et al (2018), which looked at driving simulators in the clinical assessment of FTD, suggested that in general, simulated driving did not reliably predict real-life motor vehicle accidents, and especially not at an individual level, despite the moderate relationship between simulated and real-road test driving performance. The severity of sleepiness is most likely not the critical factor leading to motor vehicle accidents, but rather the perception of sleepiness. As a result, these studies suggest the awareness and perception of sleepiness are important considerations in driving performance and decisions to stop/pause driving for breaks and for predicting accident rates, though more research on subjective sleepiness in controlled environments is needed as suggested by Cai et al.

The Monash review of sleepiness and MVC risk included 37 studies. Most studies (33) addressed sleep apnoea and sleep-related breathing disorders, some including sleep apnoea severity and treatment. There were five studies of central disorders of hypersomnolence and narcolepsy, and two studies of insomnia. The review authors identified evidence for an increased motor vehicle crash risk associated with sleep disorders (including sleep apnoea, narcolepsy and insomnia). They recommend that further research should include objective measures of sleep disorders and MVC risk; measurement of driving exposure; medication use/compliance; comorbidities and disorder severity. They recommend a population-based controlled study be carried out across multiple sites. They further recommend research should focus on sleep disorders and crash risk among commercial (Group 2) drivers due to the limited evidence.

7.12 Vision

Good vision is fundamental to safe driving. The prevalence of visual impairment is estimated to be about 596 million worldwide (Burton et al., 2021). Cataracts, age-related macular degeneration (AMD), glaucoma and diabetic retinopathy are the leading causes of visual impairment, particularly in older adults (Flaxman et al., 2017). All of these conditions can negatively affect FTD.

The literature search identified 4996 papers related to vision and driving, of these Endnote software identified 76 systematic reviews. After screening, eight reviews met the inclusion criteria for data extraction. However, five were only marginally relevant or summarised already: one review covered the specific topic of second eye cataract surgery; another review was on rehabilitation for drivers with low vision; another was on interventions for older drivers, one of which was useful field of view; one review was on vision impairment and traffic safety outcomes in low-income and middle-income countries, which specifically excluded high income countries.

A review by Wood presents the same information as that in the Monash report summarised below. The remaining three studies are summarised below:

Desapriya et al (2014) carried out a Cochrane review of vision screening of older drivers for preventing road traffic injuries and fatalities. They provided the following background to this review: 'Several age-related processes/conditions impair vision, thus it follows that vision testing of older drivers is an important road safety issue. The components of visual function essential for driving are acuity, static acuity, dynamic acuity, visual fields, visual attention, depth perception, and contrast sensitivity. These indices are typically not fully assessed by licensing agencies. Also, current vision screening regulations and cut-off values required to pass a licensing test vary from country to country. Although there is a clear need to develop evidence-based and validated tools for vision screening for driving, the effectiveness of existing vision screening tools remains unclear. This represents an important and highly warranted initiative to increase road safety worldwide to assess the effects of vision screening interventions for older drivers to prevent road traffic injuries and fatalities.' The authors searched for randomised controlled trials of before and after studies comparing vision screening to non-screening of drivers aged 55 years and older, and which assessed the effect on road traffic crashes, injuries, fatalities and any involvement in traffic law violations. However, no studies were found that met the inclusion criteria for this review. The authors concluded that although most countries require a vision screening test for the renewal of an individual's driver's licence, there is a lack of methodologically sound studies to assess the effects of vision screening tests on subsequent motor vehicle crash reduction. They recommended that future research is needed to develop valid and reliable tools of vision screening that can predict driving performance.

Kumar et al (2016) carried out a systematic review of visual acuity standards world-wide for driving. The rationale for the review was that visual acuity forms the basis of determining an individual's FTD around the world. The objective of the review was to examine the visual acuity requirements to legally drive in countries around the world and the evidence supporting them. The review collected driving standards from all around the world, utilizing government resources, websites and journal articles. Countries spanning across Oceania, Asia, Europe, America, Africa, Middle East and the United Kingdom were assessed. All countries have a minimum visual acuity standard - the most commonly adopted being 6/12. There is a lack of uniformity in how visual acuity is determined, with countries using different scales such as Snellen, logMAR and the EU metric visual acuity notations. The authors concluded that there is a lack of unity amongst countries and insufficient evidence to support current standards, and highlighted the need to determine an internationally consistent baseline standard. They recommended that further research is needed on this issue.

Strong et al (2008) conducted a systematic review to examine whether vision-related assessments can predict the driving performance of individuals who have low vision. They concluded that measures of visual field, contrast sensitivity, cognitive and attention-based tests, and driver screening tools have variable utility for predicting real-world driving performance.

Wood et al (2022) conducted a systematic review of visual disorders and MVC risk. The results of this review are published within the Monash report as detailed below.

The Monash review on vision and MVC risk included 48 studies but only 18 were rated as of good quality. However, most of these reported data on only relatively small numbers of drivers with visual impairment. The authors recommend future well-designed studies with a larger sample size involving drivers with a range of visual loss and impairment on MVC risk and on-road driving performance. More studies on FTD with common eye conditions such as cataract, glaucoma, AMD and diabetic retinopathy are recommended, as well as studies on the binocular visual fields necessary for safe driving. They suggest that such studies are necessary to

develop evidence-based recommendations which can be used by policy makers and clinicians. This review is now also published as Wood et al (2022) in Acta Ophthalmologica.

7.13 Multiple conditions

Most medical guidelines on FTD are condition specific, with few considering how a combination of medical conditions, and potentially multiple medications, may affect FTD. However, many drivers are likely to have more than one condition that may affect their FTD, and this is especially the case among older drivers.

As part of the Monash review, a rapid review examined the evidence of MVC risk and multiple medical conditions. Sixteen studies were included but only six were rated as being of good quality. Of these six, two reported a small increased risk of MVC for patients with multiple unspecified chronic medical conditions. Two further 'good' studies examined sleep apnoea and comorbidities but found no increase in MVC risk. Two other 'good' studies examined MVC risk for diabetes and its complications, one reported an increased risk, the other found no difference. The review authors concluded that there is limited research evidence on multiple medical conditions and MVC risk and recommend future research on this topic, in particular a large scale prospective population-based controlled study.

7.15 Professional drivers

Professional drivers was not a specific topic, but our search terms included professional drivers to ensure that papers on commercial and professional drivers were captured. Given the high mileage covered by professional and commercial drivers, it is important to consider medical conditions that particularly affect them. The DVLA medical standards are far more stringent for Group 2 drivers, and these drivers have regular medical checks in order to renew their Group 2 licence. However, the Covid pandemic and consequent shortage of HGV drivers has led to a shortening of the HGV test to encourage new recruits, which has been criticised by some insurers (Commercial Fleet, 2021).

The literature review identified a number of conditions which have been linked with crash risk for drivers of Group 2 vehicles.

Sharwood et al (2011) carried out a systematic review to investigate the role of fatigue, sleep and sleep disorders in commercial vehicle crashes. They included 16 studies in their review and found that daytime sleepiness and sleep debt were associated with increased crash risk. They also reported that obesity was a risk factor for sleep disorders, daytime sleepiness and incurring a crash or near miss. However, most of the included studies were of small sample size and suffered from methodical flaws. The authors recommended a need for a large, well-designed study with empirical measures of both risk factors and outcomes.

Mabry et al (2016) carried out a systematic review into the prevalence of metabolic syndrome (MetSyn) in commercial truck drivers as identification of MetSyn may benefit early recognition of risk for cardiovascular disease. They included 27 studies which included data on between 30 to 88,246 commercial truck drivers. The studies reported that 23-53% of CTDs were overweight, 15-70% were obese; 5-48% had hypertension; 7-46% had dyslipidemia; 1-22% had diabetes; and 19-74% had abdominal obesity which is a particular risk factor for cardiovascular disease. The authors recommended that research is needed to evaluate a large representative group of commercial truck drivers to collect measured indices of MetSyn. They also recommended health intervention studies for truck drivers focusing on obesity prevention, management and treatment.

Phillips et al (2015) carried out a review of driver fatigue among professional operators of different transport forms in Norway. Prevalence rates of fatigue among Norwegian drivers varied according to the type of professional driver surveyed. This was reflected by data showing that the proportion of drivers reporting falling asleep behind the wheel (at any time) is higher for long distance drivers (42%) than for local transport drivers (34%). Thus, sleepiness rates among long-distance bus and truck drivers may be higher than for drivers of local routes. Rates of mental or physical exhaustion may also vary within road transport, according to particular job tasks. The authors concluded that there is a lack of evidence to relate work schedules to sleep and fatigue in the Norwegian road transport sector. Norwegian studies do suggest, however, that professional drivers (who arguably need it most) get substantially less sleep than some other occupations, with almost 1 in 4 drivers getting less than six hours sleep on a normal week night.

7.15 The role of health professionals

The DfT commissioned project on the attitudes of health professionals to giving advice on FTD (Hawley, 2010) found that there were many barriers to giving advice to patients. These included a lack of training; lack of time; forgetting to mention driving due to more pressing concerns about the patient's health; assuming that older patients did not drive; lacking knowledge of the driving rules for various medical conditions; and concerns about jeopardising the doctor/patient relationship. Facilitators included the patient raising the question of driving during consultations; clear guidelines; reliable screening tests; and having somewhere to refer patients on to for assessment. Recommendations were made for better education and training for doctors and other health professionals. It was further recommended that education on medical aspects of FTD be included in the core syllabus for doctors in training at UK medical schools.

The current literature suggests that these training recommendations have not yet been fully met. Azawi et al (2020) examined inclusion of medical FTD (MFTD) in the curricula of postgraduate core, higher and streamlined medical and surgical specialties in the Republic of Ireland and the UK. In Ireland, 25% of basic training schemes included MFTD in the curriculum. For the UK 44% of core and 36% of higher training scheme curricula included MFTD. However, under one-quarter of all curricula reviewed included MFTD for more than one medical condition or treatment. The authors concluded that there are notable deficits in MFTD training for specialists in Ireland and the UK and that common conditions which can significantly impair MFTD such as stroke, diabetes and alcohol use disorders are severely underrepresented. They recommended that curricula should be revisited to include relevant training and guidance on MFTD.

Berry (2011) highlighted the role of health professionals in advising older drivers on their medical FTD. He recommended that when renewing their licence via self-certification, older drivers should be required to declare that they have sought the advice of their GP before completing the relevant forms. He argued that this would not place undue responsibility on GPs, but instead would act as a trigger for older people to themselves seek out advice and information. He recommended that more advice and training be provided to GPs, along with greater financial incentives in order to perform this role. He suggested that if road safety became a concern of public authorities focused on health, such as the Department of Health and the NHS, this would aid policymaking on older driving and also help GPs to play a more systematic role in older people's self-regulation.

The Hawley and Berry studies were carried out over ten years ago, however a review of the current literature suggests that the problem of giving appropriate driving advice to patients persists. A recent German study (Leve et al, 2021) examined GPs knowledge of which older patients (aged ≥85 years) drive a car and if FTD is addressed with patients. They found that GPs recognised two thirds of the driving patients, but had discussed FTD with only 32% of these. In Australia, a survey of hospital doctors was carried out to ascertain knowledge and attitudes to discussing FTD with patients (Shanahan et al, 2007). The authors concluded that public hospital doctors in Australia have poor knowledge of the content of published guidelines in the area of FTD, and many are uncomfortable with their responsibilities in this area. They recommended that further education was needed together with alternative models of decision-making.

The IAM RoadSmart report on older drivers (Hawley, 2021) also made recommendations about the role of health professionals in giving advice on FTD. They found that older drivers rated GPs and Opticians/Optometrists as the most trusted and influential advisers on FTD, but the role of these professionals in sharing information and advising on giving up driving must be clarified. The authors also recommended training for medical professionals and Opticians/Optometrists in the detection of driving issues, the best ways to discuss driving and the offering of advice. They noted that this should be done in consultation with the professional governing bodies and colleges.

8. Conclusions

This review of the literature has discovered that a great deal of research has been carried out on the topic of FTD. From research registers of current and proposed studies we also identified almost 200 studies on FTD which are either planned or in progress.

In this review we had to restrict ourselves to close reading of systematic reviews of the evidence. Consequently, there are many more studies we did not include which would provide important information and insights but may not meet the high methodological quality required for inclusion in systematic reviews. The grey literature was a useful source of information. It has predominantly focused on groups of at-risk drivers such as young and novice drivers; older drivers; drivers impaired by alcohol and drivers impaired by drugs. Whereas the published literature has often been concerned with specific medical conditions and FTD, with many reviews examining impairments, crash risk, assessment and screening tools. Some topics and medical conditions have received far more attention than others

We carefully reviewed all systematic reviews and reports for 18 medical conditions which can affect FTD as well as reviews and reports for the topics of older drivers, younger drivers, professional drivers, and health professionals. We identified important gaps in the research evidence where there is potential for new research which can improve road safety, particularly in the UK. From the review we identified a substantial list of recommendations for future research, with most medical conditions and topics needing more evidence to help inform policy decisions and medical guidelines.

For older drivers we identified two large comprehensive programmes of research, Candrive and Ozcandrive, which require substantial investment, and both are funded by collaborations between governments and research councils. Something similar would be beneficial to the UK, but too costly for one organisation to fund. However, elements of these programmes would be worth funding and would provide significant benefits.

We recommend ten conditions/topics for the RST to consider when deciding their priorities for funding under the topic of 'Fitness to Drive'. In making our recommendations we have focused on those areas which are feasible for the RST to include in their call for funding proposals, and which will benefit drivers and road safety in the UK.

9. Recommendations

After a careful review of the available evidence and identification of research gaps, the following topics are recommended as areas for the RST to focus on in their forthcoming funding call on FTD. Research in these areas will address research gaps and has the potential to influence policy and improve road safety.

9.1 Older drivers

Older drivers have been the focus of considerable research spending and research effort in several developed countries, as evidenced in the summaries above in section 7.4.1. Although much work has already been done, answers are still being sought to questions regarding FTD among older people. A careful balance is needed to allow, on the one hand, safe and competent older drivers to continue to drive, stay mobile and enjoy the many social and psychological benefits driving gives them, whilst on the other hand, identifying those older drivers who may pose a danger to themselves and other road users. This has been a challenge faced by policy makers for many years, becoming more urgent due to the increasing number of 'older drivers' on the road, with over 65 year olds currently forming 22% of GB driving licence holders. Consequently, the topic of older drivers is recommended for consideration by the RST. Within this topic the following areas are recommended for attention.

Self assessment tools for older drivers

The review by Lang et al (2013), described above, examined self-assessment tools for older drivers, concluding that these are useful. At the time of the review, computer and web-based solutions for self-assessment were not seen as particularly useful for older people as only a minority of older drivers were then computer literate. However, currently many older drivers have access to the internet and have become competent users, so web-based assessment tools are now likely to gain acceptance. Recent research by IAM RoadSmart found that if such self-assessment tools of FTD were available most older drivers said they would use them. Consequently, the development of online self-assessment tools should be considered for funding, as these have the potential to provide drivers with tailored feedback to drivers of different abilities and needs, and are likely to be accepted by older drivers.

Older drivers with multiple medical conditions and multiple medications

Most older drivers do not have a higher crash risk than younger drivers. Driving experience and a willingness to regulate their driving in challenging conditions, such as avoiding driving at night and in bad weather, means that most older people are safe drivers. However, most of the medical conditions that affect FTD become more common as we age. Also, there is an increased likelihood of older drivers having multiple medical conditions which may require multiple medications. These comorbidities and multiple medications increase the risk of a MVC. It is recommended that the topic of older drivers with multiple medical conditions and taking multiple medications be considered for funding by the RST.

9.2 Brain Injury

Brain and head injuries are common, and are associated with many persistent functional and cognitive impairments which can impair FTD. This review has identified a need for research to determine a consistent and standardised approach to assessing FTD following traumatic brain injury, particularly mild TBI.

9.3 Dementia (all types)

In the UK, research carried out for the Alzheimer's Society has estimated that there were 885,000 people aged 65 and over with dementia in 2019, with a prevalence rate of 7.1%. These figures are projected to rise to one million by 2024, and to rise to 1,233,400 in 2030 (Wittenberg et al, 2019). It has been suggested that driving problems may be an early sign of dementia, because of the great demands for selective attention, judgment, and visual interpretation (Staplin et al. (2012).

Due to the progressive nature of this degenerative disease which affects multiple cognitive impairments, there will come a point when sufferers are unfit to drive. Because many patients continue to drive for some time after the onset of their illness, and because of the lack of insight that is a consequence of the disease, it is vitally important that health professionals assess the driving safety of their patients and offer driving advice appropriately in a timely manner.

The evidence reviewed suggests that FTD is severely impaired in moderate and severe dementia, irrespective of the type of dementia, including Parkinson's disease. Furthermore, mild cognitive impairment, which is often experienced before a formal diagnosis of dementia, is associated with driving risk. There remains a need for effective screening tests to identify patients in the early stages of dementia who are unfit to drive. It is therefore recommended that all forms of dementia and FTD is a topic which should be considered for funding by the RST.

9.4 Diabetes

Diabetes is a common condition with approximately 4 million adults with diabetes in the UK. There are clear research gaps in the area of diabetes and driving. A major concern for drivers with diabetes is the risk of a hypoglycaemic episode which can cause confusion and potential loss of consciousness. Complications of diabetes can affect FTD, such as visual complications and peripheral neuropathy.

Suggested research topics are:

a) the relationship between diabetes and crash risk for commercial drivers

b) the best ways of identifying drivers susceptible to experiencing hypoglycaemia, and

c) diabetic peripheral neuropathy and driving as this may contribute to pedal confusion

9.5 Prescription drugs

Each year over one billion prescription items are dispensed from pharmacies in England alone (Statista, 2022). Medicines that can seriously impair driving (antidepressants, opioids, gabapentinoids, benzodiazepines, and sleeping tablets) were prescribed for 16.8 million people in England during the financial year 2017/18 (Public Health England, 2020). This review of the literature has identified the importance of the topic of prescription medications/drugs and over the counter medications to FTD. The systematic reviews we examined identified several areas where new research is needed. In particular, we recommend that research should examine how combinations of medications may affect FTD, and what advice is given to patients

regarding the effects of medications on driving. Research should also be carried out to examine the relationship between medication use, driving impairment and crash risk.

9.6 Sleep and fatigue

Sleep disorders are common. A review of the available evidence suggests that there is an increased MVC risk associated with sleep disorders (including OSA, narcolepsy and insomnia). In particular, OSA is a common condition, with an estimated 1.5 million adults in the UK living with OSA, yet up to 85% are undiagnosed and may be putting themselves and other road users at risk. OSA is more prevalent among older adults, men and those that are overweight. There is some evidence that commercial drivers and HGV drivers are at particular risk of OSA due to an unhealthy diet and lack of exercise (i.e. long hours spent sitting down driving). OSA brings a risk of excessive sleepiness, with an elevated risk during hours of darkness. Work and shift patterns of commercial and HGV drivers often mean they spend considerable time driving during darkness.

This scoping review of the evidence suggests that further research should be carried out on sleep disorders and FTD using a population-based controlled study which includes measures of comorbidities and medication use.

Due to a lack of current evidence, research should also be carried out on sleep disorders and crash risk among Group 2 drivers. It is therefore recommended that sleep disorders and FTD is a topic which should be considered for funding by the RST.

9.7 Vision

Both the current review and the Monash review recommend that visual impairment and FTD should be the focus of future research. Many previous studies have noted that the visual standards for driver licencing vary considerably around the world. The UK has one of the most lenient visual standards, in that after passing the driving test a driver can continue to drive until the age of 70 without any formal checks on their vision. When the driver must renew their licence at age 70 there is no requirement for an eyesight test, which is the case in many other countries. In the UK several authors have commented on this and have recommended mandatory eyesight tests at regular intervals, however there is no clear evidence that visual impairment is a major cause of motor vehicle accidents. It is recommended that research is carried out to assess the MVC risk attributable to impaired vision with a view to influencing policy change to improve eyesight standards for driving in the UK.

9.8 Professional and commercial drivers

Fitness to drive among professional and commercial drivers has received little research attention. However, the nature of their work places these drivers at risk. Time pressures can cause anxiety, the sedentary nature of the work (sitting for long hours) and often poor diet can increase the risk of obesity, cardiac disorders, diabetes, fatigue and sleep disorders. Commercial drivers are at increased risk for OSA as described above. Although DVLA driving standards are more strict for Group 2 drivers, drivers of vans and small delivery vehicles are likely to be driving with a Group 1 licence which have more lenient medical standards.

It is recommended that research be carried out on FTD among professional and commercial drivers.

In particular, research should investigate the role of fatigue, sleep and sleep disorders in commercial drivers and crash risk, as identified above in section 10.6.

9.9 Health professionals

The role of health professionals on advising their patients on FTD is fundamental to medical licensing. Patients are often unaware of how their medical condition, or combination of medical conditions and medications may affect their FTD. They rely on health professionals to advise them, but with all of the competing pressures on doctors, especially GPs, it is difficult to find time to give advice on driving and remembering to do it. There is evidence from earlier studies that health professionals often do not feel sufficiently knowledgeable about the medical rules for driving, and there are concerns that advising a patient not to drive may negatively affect the doctor:patient relationship.

It is recommended that the current state of knowledge on FTD among doctors is assessed, and education and training packages are developed on giving patients advice on FTD. It is also important to develop training for doctors in considering the cumulative effect of multiple medical conditions in combination with multiple medications, and how these may impact on FTD. Training is also needed in when and how doctors should refer patients for a driving assessment so driving aids or adaptations can be prescribed.

Research in this area has the potential to improve doctor's knowledge of medical aspects of FTD and ensure that patients who should not drive receive appropriate advice, assessment and support. It also has the potential to improve the reporting of medical conditions to the DVLA and thus improve road safety.

9.10 A full systematic review

This scoping review has unearthed a wealth of research on the topic of FTD in general and in relation to specific medical conditions. In this short review we were able to examine the evidence summarised in published systematic reviews and in the grey literature. However, there are hundreds of studies which will not have been included in systematic reviews. We therefore recommend that a full systematic review be carried out for the topics recommended for funding under this call by the RST.

10. Study limitations

This rapid scoping review was carried out over a very short timescale, condensing a literature review that would normally take at least six months into under 6 weeks. Consequently, there are some limitations which are identified as follows:

Due to the high number of publications returned from the database searches we had to rely on Endnote software to find and remove duplicated papers. The software is not perfect and many duplicates remained, so total numbers of papers reported are likely to be overestimates.

The search terms used were the best we could derive in the timescale, but with more time these could be further refined to minimise the number of irrelevant papers.

Within the short timescale, it was necessary to restrict the close reading of full text articles identified by the database searches to systematic reviews. A great many useful papers on FTD were identified in the searches, but as they were not systematic reviews it was not possible to include them in this review. Additionally, there is a wealth of information in the 'grey literature'. Often these were lengthy reports, and due to the short timescale available we had to be selective as to those we included in this review. We recommend that future studies include a systematic review of the full literature base for each selected topic of interest.

11. UK data on factors affecting fitness to drive

Part of the study brief was to examine the available data sources on factors affecting FTD. A website search was carried out to identify UK data sources. One of the most useful sources of driving data is that derived from STATS19 collision data. The STATS19 system allows police forces to report all personal injury collisions taking place on public roads. These statistics are published annually by the Department for Transport and are available for download from the data.gov.uk website:

https://data.gov.uk/dataset/cb7ae6f0-4be6-4935-9277-47e5ce24a11f/road-safety-data

The most recently available data were published on 25th November 2021. Data are available on accidents, vehicles and casualties. Full data are available for 2020, and provisional mid-year data for 2021.

The Department for Transport also publish detailed statistics about reported personal injury road accidents for Great Britain, vehicles and casualties. These are freely available for download from the gov.uk website:

https://www.gov.uk/government/statistical-data-sets/reported-road-accidents-vehicles-and-casualties-tables-for-great-britain

Statistics on the factors contributing to road collisions are also reported by the DfT and available for download on the gov.uk website: https://www.gov.uk/government/statistical-data-sets/reported-road-accidents-vehicles-and-casualties-tables-for-great-britain#contributory-factors-for-reported-road-accidents-ras50

These data tables are based on the contributory factor (CFs) data collected as part of STATS19. There is a section of CFs for impairment or distraction. The CFs most relevant to FTD are:

- Driver/rider impaired by alcohol
- Driver/rider impaired by drugs (illicit of medicinal)
- Fatigue
- Uncorrected, defective eyesight
- Driver/Rider illness or disability, mental or physical
- Driver using mobile phone

However, contributory factors are not particularly useful for evaluating FTD as the CFs on illness and disability and on eyesight are infrequently used by police attending a collision. At the roadside, police are unlikely to be aware of medical conditions, and police are only able to check a driver's eyesight in daylight. Police are also restricted to using up to six CFs so if other CFs are deemed more important to the collision than illness and eyesight they may not be recorded. These factors lead to under-reporting.

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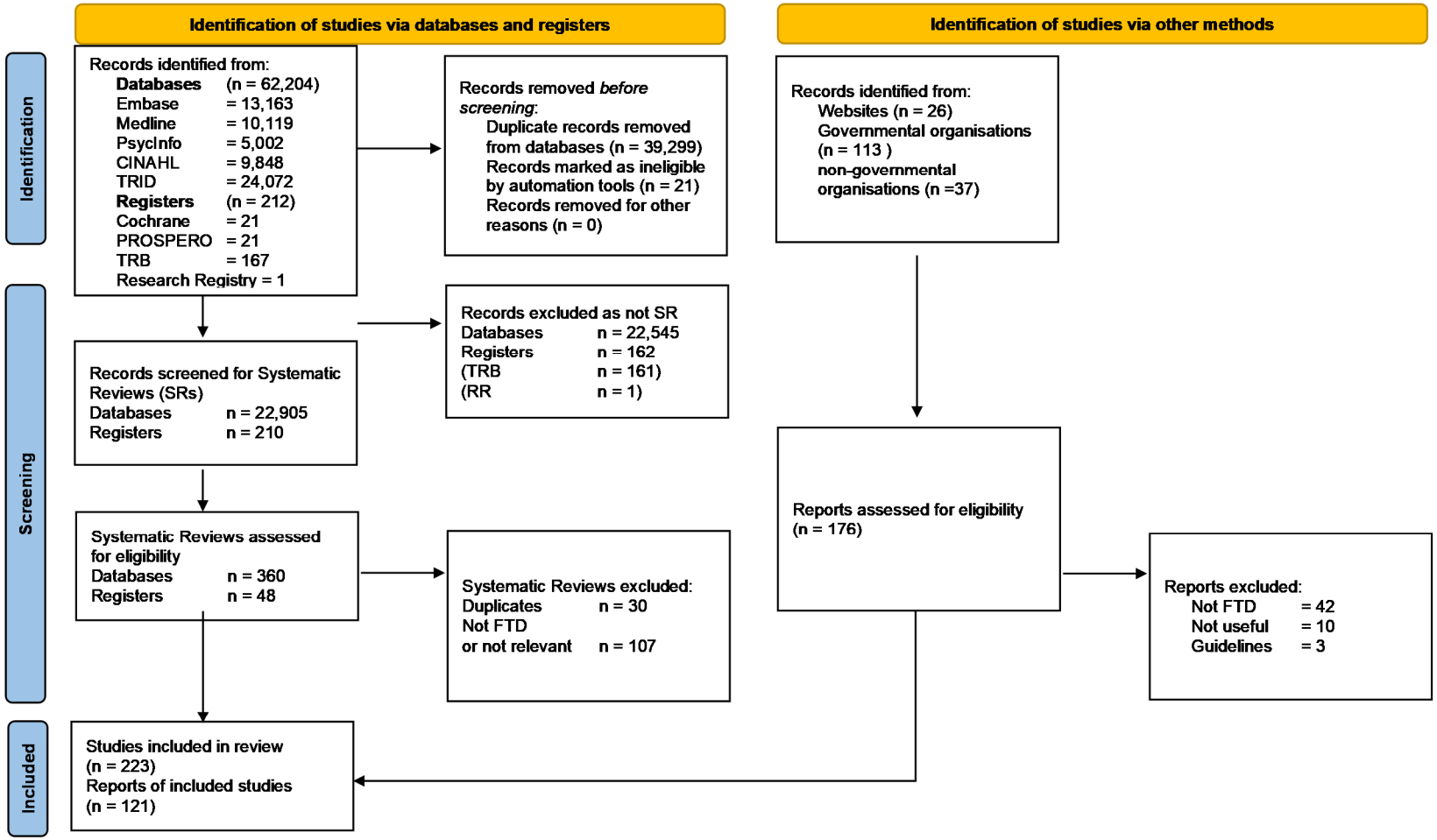
Appendix I The PRISMA Flow Diagram



From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

Appendix II Search terms used for Search 2: conditions and topics (using Embase as an example)

Vision searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. 1 OR 5
7. Glaucoma or Cataract or Macular Degeneration or Hemianopsia or Diabetic Retinopathy or Visual Acuity or Visual Fields or Vision Disorders or Blindness or Vision Ocular or Eye Diseases or Glaucoma or Cataract* or Macular Degeneration or Hemianopsia or Retinopathy or Diabetic Retinopathy or Visual Acuity or Contrast sensitivity or visual field* or visual impairmen* or impaired vision or vision loss or vision or ocular disease* or eye disease* or ocular condition or eye condition
8. 6 + 7
9. limit 8 to (human and english language and yr="2000 -Current")

Alcohol use/misuse/disorder searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. 1 OR 5
7. Alcohol-related disorder or Alcohol related problem or Alcohol-use disorder or Alcohol dependence or Alcoholism or Alcohol misuse or Alcohol abuse or Binge drinking or Alcohol addiction or Driving offence or Driving under the influence or DUI or AUD or Drunk driving or Alcohol impaired driving or Alcohol related injuries
8. 6 + 7
9. limit 8 to (human and english language and yr="2000 -Current")

Diabetes searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. limit 8 to (english language and yr="2000 -Current")

Drug/substance misuse searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. 1 OR 5
7. substance misuse* or substance abuse* or substance disorders or substance related disorders or intravenous substance abuse* or oral substance abuse* or substance withdrawal syndrome or narcotics use* or narcotics abuse* or narcotics disorders or IDU or PWID or injection drug use* or intravenous drug use*
8. 6 + 7
9. limit 8 to (human, english language and yr="2000 -Current")

Sleepiness, fatigue, drowsiness and sleep disorders searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. (Sleep Wake Disorders or Sleep Apnea Syndromes or Narcolepsy or REM Sleep Behavior Disorder or Continous Positive Airway Pressure or sleep disord* or sleep apnea or sleep apnoea or narcolep* or CPAP or drowsy driving or Sleep Stage or Drowsiness or fatigue alertness or sleepiness alertness or Fatigue management or sleepiness management or Sleep or forced desynchrony).mp.
8. 6 + 7
9. limit 8 to (english language and yr="2000 -Current")
10. limit 9 to human

Brain injury, epilepsy and related neurological searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. Exp epilepsy/or exp epilepsies, myoclonic/or exp epilepsies, partial/or exp epilepsy, complex partial/or exp epilepsy, frontal lobe/or exp epilepsy, partial, motor/or exp epilepsy, partial, sensory/or exp epilepsy, rolandic/or exp epilepsy, temporal lobe/or exp epilepsy, benign

neonatal/or exp epilepsy, generalised/or exp epilepsy, post-traumatic/or exp epilepsy, reflex/or exp landau-kleffner syndrome/

8. Epilepsy.tw.
9. 7 OR 8
10. Exp seizures/or exp seizures, febrile/or exp status epilepticus/or exp epilepsia partialis continua/
11. Seizure$.tw.
12. Stroke$.mp. or exp Cerebrovascular Accident/ or exp subarachnoid hemorrhage, traumatic/
13. Initial seizure.mp.
14. ("Loss of consciousness" or blackout$).mp.
15. (Epilepsy or seizure$ or fit or fits).tw.
16. ((Brain or head or skull or neurological or cerebral) and (injur$ or damag$ or trauma$ or surgery or surgical or insult$ or infection$ or tumour$ or tumor$ or neoplasm$ or abscess$ metastases)).mp.
17. (Cerebral arteriovenous and (malformation or malformations)).mp.
18. Exp brain diseases/or exp brain abscess/or exp brain damage, chronic/or exp brain injury, chronic/or exp brain diseases, metabolic/or exp brain edema/or exp brain injuries/or exp brain concussion/or exp brain hemorrhage, traumatic/or exp cerebral hemorrhage, traumatic/or exp diffuse axonal injury/or exp epilepsy, post-traumatic/or exp pneumocephalus/or exp brain neoplasms/or exp cerebellar diseases/or exp cerebrovascular disorders/or exp brain ischemia/or exp carotid artery diseases/or exp cerebrovascular accident/or exp brain infarction/or exp cerebral infarction/or dementia, vascular/or exp dementia, multi-infarct/or exp ischemic attack, transient/or exp hypoxia, brain/or exp cerebral arterial diseases/or exp intracranial aneurysm/or exp intracranial arteriovenous malformations/or exp intracranial hemorrhages/or exp cerebral hemorrhage/or exp hematoma, epidural/or exp hematoma, subdural/or exp subarachnoid hemorrhage/or exp subarachnoid hemorrhage, traumatic/or exp encephalitis/or exp hydrocephalus/or exp meningitis/
19. 9 – 19 (OR)
20. 6 + 21
21. limit 22 to (english language and yr="2000 -Current")
22. limit 23 to humans

Hearing searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. auditory perception/ or auditory threshold/ or loudness perception/ or perceptual masking/ or pitch perception/ or sound localization/ or speech perception/ or timbre perception/
8. auditory diseases, central/ or auditory perceptual disorders/ or hearing loss, central/ or vestibulocochlear nerve diseases/
9. hearing disorders/ or hearing loss/ or deafness/ or deaf-blind disorders/ or usher syndromes/ or wolfram syndrome/ or hearing loss, bilateral/ or hearing loss, conductive/ or hearing loss, functional/ or hearing loss, high-frequency/ or hearing loss, mixed conductive-sensorineural/ or hearing loss, sensorineural/ or hearing loss, sudden/ or hearing loss, unilateral/ or hyperacusis/ or tinnitus/ or herpes zoster oticus/ or labyrinth diseases/ or myringosclerosis/ or otitis/ or otomycosis/ or otosclerosis/ or ototoxicity/ or retrocochlear diseases/ or susac syndrome/ or tympanic membrane perforation/
10. 7 OR 8 OR 9

11. 6 + 10
12. Limit 11 to (English language, 2000-2022)
13. Limit 12 to human

Cardiovascular searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. exp cerebrovascular accident/ or exp hypertension/ or exp hypercholesterolemia/ or exp heart infarction/ or exp congestive heart failure/ or exp multiinfarct dementia/ or stroke*.mp. or cerebrovascular accident.mp. or cerebrovascular apoplexy.mp. or cerebrovascular lesion.mp. or brain accident.mp. or brain attack.mp. or brain insultus.mp. or brain vascular accident.mp. or cerebrovascular failure.mp. or cerebrovascular injury.mp. or leukoaraiosis.mp. or white matter.mp. or hypertension.mp. or hypertensive.mp. or high blood pressure.mp. or hypercholesterolemia.mp. or high cholesterol.mp. or elevated cholesterol.mp. or hypercholesterinaemia.mp. or hypercholesterinemia.mp. or hypercholesterolaemia.mp. or heart attack.mp. or myocardial infarct*.mp. or heart infarct*.mp. or cardiac infarct*.mp. or myocardium infarct*.mp. or subendocardial infarct*.mp. or cardiovascular stroke.mp. or congestive heart failure.mp. or congestive cardiac failure.mp. or congestive heart insufficiency.mp. or CHF.mp. or vascular dementia.mp. or arteriosclerotic dementia.mp. or Binswanger disease.mp. or Binswanger encephalopathy.mp. or subcortical leukoencephalopathy.mp. or multi-infarct* dementia.mp. or multiinfarct dementia.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword heading word, floating subheading word, candidate term word]
8. 6 + 7
9. Limit 8 to (English language, 2000-2022)
10. Limit 9 to human

Older/younger/age of drivers searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. (driv* age or age driv* or older driv* or aging driver* or ageing driver* or geriatric driv* or senior driv* or elderly driv* or senior citizen driv* or young* driver* or new driver* or newly qualified driv* or youth driv* or teen* driv* or novice driver* or young adult driv*).mp.
8. 6 + 7

Mental disorders searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*

3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. mental disease/ or addiction/ or alexithymia/ or anxiety disorder/ or autism/ or behavior disorder/ or confusion/ or delirium/ or dissociative disorder/ or emotional disorder/ or experimental mental disease/ or learning disorder/ or memory disorder/ or mental deficiency/ or mental instability/ or mental overstimulation/ or mood disorder/ or neurosis/ or organic brain syndrome/ or personality disorder/ or psychosis/ or psychotrauma/ or schizophrenia spectrum disorder/ or thought disorder/ or mental dissociation/
8. 7 + 8
9. limit 8 to (english language and yr="2000 -Current")
10. limit 9 to human

Respiratory conditions

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* or behavior* or abilit* or risk or fitness
5. 2 + 4
6. 1 OR 5
7. chronic obstructive pulmonary disease/ or cystic fibrosis/ or pneumonia/ or pulmonary emphysema/ or pulmonary tuberculosis/ or exp Chronic Obstructive Pulmonary Disease/ or respiratory tract disorders/ or apnea/ or bronchial disorders/ or dyspnea/ or lung disorders/ or pharyngeal disorders/ or severe acute respiratory syndrome/ or emphysema.mp. or chronic airway obstruction.mp. or bronchitis.mp. or COPD.mp. or pulmonary disease.mp. or exp Sleep Apnea/ or airway disease.mp. or exp Asthma/ or exp Respiratory Tract Disorders/ or exp COVID-19/ or respiratory tract disease.mp.
8. 7 + 8
9. limit 8 to (english language and yr="2000 -Current")
10. limit 9 to human

Musculoskeletal conditions

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. 1 OR 5
7. musculoskeletal disease/ or arthropathy/ or bone disease/ or chondropathy/ or contracture/ or enthesopathy/ or fascia disease/ or ligament disease/ or limb disease/ or morning stiffness/ or muscle disease/ or musculoskeletal chest pain/ or musculoskeletal infection/ or musculoskeletal injury/ or musculoskeletal pain/ or musculoskeletal stiffness/ or musculoskeletal system inflammation/ or musculoskeletal system malformation/ or pseudoparalysis/ or rigor/ or tendon disease/
8. knee arthritis/ or Lyme arthritis/ or chronic arthritis/ or gonococcal arthritis/ or juvenile rheumatoid arthritis/ or caprine arthritis encephalitis/ or pristane-induced arthritis/ or arthritis/ or Caprine arthritis encephalitis virus/ or adjuvant arthritis/ or arthritis.mp. or systemic juvenile idiopathic arthritis/ or Candida arthritis/ or proteoglycan-induced arthritis/ or zymosan-induced arthritis/ or

bacterial arthritis/ or hemorrhagic arthritis/ or shoulder arthritis/ or streptococcal cell wall-induced arthritis/ or psoriatic arthritis/ or experimental arthritis/ or reactive arthritis/ or Arthritis Impact Measurement Scales/ or tuberculous arthritis/ or formaldehyde-induced arthritis/ or collagen-induced arthritis/ or rheumatoid arthritis/ or infectious arthritis/ or collagen antibody-induced arthritis/ or ankle arthritis/

9. secondary osteoporosis/ or posttraumatic osteoporosis/ or involutional osteoporosis/ or corticosteroid induced osteoporosis/ or juvenile osteoporosis/ or postmenopause osteoporosis/ or senile osteoporosis/ or experimental osteoporosis/ or ovariectomy-induced osteoporosis/ or osteoporosis/ or idiopathic osteoporosis/ or osteoporosis.mp. or osteoporosis pseudoglioma syndrome/ or primary osteoporosis/
10. sickle cell.mp. or sickle cell/
11. hip pain.mp. or hip pain/
12. knee pain.mp. or knee pain/
13. lower back pain.mp. or low back pain/
14. lupus.mp. or lupus vulgaris/
15. carpal tunnel syndrome/ or cumulative trauma disorder/ or mononeuropathy/ or neuralgia/ or periarticular joint disease/ or wrist disease/
16. OR (7-15)
17. 6 + 16
18. Limit 17 to Limit 9 to (English language, 2000-2022, human)

Prescription drugs searches

Ovid Embase

1. fitness drive OR fitness-to-drive OR fit drive
2. automobile driving or car driving or motor-car driving or motorcyclist or motor-car or motorist* or motor-vehicle*
3. 1 OR 2
4. competen* or skill* or assess* or safe* or attitud* or behaviour* OR behavior* OR abilit* OR risk OR fitness
5. 2 + 4
6. 1 OR 5
7. exp prescription drug/
8. 6 + 7
9. Limit 8 to (English language, 2000-2022)

Appendix III Data Extraction form for Systematic Reviews

RST Data Extraction form **Data extracted by: C/H** **Include in review? Y/N**

Review Title	
First Author	
Year of publication	
Where published? journal, report, etc.	
Source origin / country of origin	
Was SR peer reviewed	
Condition or topic studied	
Type of review: Systematic review, Literature review, Scoping review, Mapping review,	
Review Objectives	
Study population and sample size (if applicable) record age, gender, driver type	
Number of studies included in review	
Range in years of included studies	
What are the inclusion/exclusion criteria?	
Does the SR's methods state the basis for inclusion or exclusion of primary studies?	
Does the SR assess the methodological quality of primary studies and take these into account?	
Does the SR discuss the reasons for any variations/heterogeneity between individual studies?	
Background to review	
Main Results	
Main conclusion of the SR	
Are the road safety implications (e.g. crash risk) for each topic/condition discussed? If yes, record	
Are recommendations made for policy or practice? If yes, record	
Does the SR identify gaps in knowledge for this topic/condition? If so record	
Are recommendations made for future research? If yes record	

Appendix IX Canadian Institutes of Health Research (CIHR) Funded projects on fitness to drive 2002 - 2021

Study title	First author	Dates funded	Summary
Pilot project on aging: Metric properties of a driving simulator for the assessment of safe driving for people in the early stage of Alzheimer's disease	Vanier	2003/4	establish the feasibility of using a simulator adapted for clinical populations, in the prediction of on-road fitness to drive of persons with early-stage Alzheimer's disease (early AD)
A virtual simulation of factors influencing older adults' line of sight during automobile driving	Gillin	2005/6 to 2006/7	automobile design, arthritic challenges affecting range of motion, reaction time changes due to aging are factors that affect line of sight during night and daytime driving. Objectives of this research are: 1)to examine factors affecting line of sight for the purpose of prolonging safe driving behaviour and, 2)to identify design deficiencies that create hazardous situations for older adults.
Drowsiness, fatigue and daytime functioning following traumatic brain injury	Beaulieu-Bonneau	2008/9 to 2012/13	research project objectives: 1 to describe the symptoms of drowsiness and fatigue following a TBI and 2 to identify the relationships between these symptoms and several areas of daily functioning (sleep, driving, alertness, psychological distress).
The CIHR Team in Driving in Older Persons (CanDRIVE II) Research Program	Man-Son-Hing	2008/9 to 2013/14	the CIHR Team in Driving in Older Persons (CanDRIVE II) research program builds on the momentum of its CIHR-funded predecessor (CanDRIVE I) in taking a national collaborative, inter-disciplinary approach to identifying, analysing and addressing issues pertaining to the mobility, injury prevention, and quality-of-life of older drivers
Attitudes and Practices of Psychologists in Canada Regarding the Driving Fitness of Older Adults	Love	2009/10 to 2011/12	examine attitudes and practices of psychologist across Canada to help understand the issue of aging and mobility. Determining how psychologists perceive the issues may be useful for the development of educational programs (for older adults, the population, and psychologists), and assist in the creation of standardized applications for assessment
Multiple medication use in the Quebec elderly and the risk of motor vehicle crash	Suissa	2010/11 to 2013/14	over 60% of Canadian elderly consume multiple medications. Many of these drugs have been implicated with impairment of the psychomotor skills required for driving and could increase the risk of

			injurious car crashes. Because we live in an aging society with an increasing number of elderly drivers, it is of interest to assess the impact of the interactions between commonly used drugs on driving safety in the elderly. This study will use the cohort of over 700,000 patients, all elderly drivers from the Province of Québec between 1999-2008
Driving in Dementia Decision Tool	Elzohairy	2013/14 to 2015/16	to adapt and evaluate a tool to help physicians decide when a patient with mild dementia should be reported to transportation authorities because their dementia has made them unsafe to drive
Driving in Alzheimer's disease and mild cognitive impairment: an immersive fMRI study	Schweizer	2014/15 to 2016/17	to combine driving simulation and brain imaging to determine the driving impairments and related brain areas that are affected by Alzheimer's disease (AD) and mild cognitive impairment (MCI)
The Grey Lane: The Link Between Health Conditions, Driving Attitudes and Driving Outcomes Among Older Adults	Walzak	2014/15	aims to investigate the role of health status in predicting driving attitudes and beliefs. It is hypothesized that health status will decrease with age, and age will also be associated to psychosocial driving measures such as decreased driving comfort, social pressure to stop driving, and poorer perceptions of driving abilities
Candrive Prospective Older Driver Study	Bédard	2014/15 to 2016/17	the CIHR Team in Driving in Older Persons (Candrive) Research Program made significant progress in collecting data to identify predictors of medically at risk drivers. However, continuation of this study is required to reach the necessary number of outcomes of at-fault motor vehicle collisions (MVCs) to create the required risk stratification tool
Driver training for patients with mild cognitive impairment	Teasdale	2014/15 to 2016/17	persons with mild cognitive impairment (MCI). will complete memory tests and other cognitive function tests and undergo a cerebral imaging examination. Participants' driving will be evaluated in "natural situations" (for 7 days); they will then undergo training sessions in a simulated environment and receive feedback on their driving errors.
A Collaborative International Knowledge Synthesis to Update Guidelines for Determining Medical Fitness to Operate Motor Vehicles	Charlton	2015/16	systematic reviews on medical fitness to drive with traumatic brain injury; dementia; psychiatric conditions.

Cognitive impairment in the real world: Linking clinical and lab-based assessments with everyday functional outcomes	Hawkins	2015/16 to 2016/17	examine the relationship between clinical assessments and performance on our simulated walking and driving tasks. The results of this work will be broadly applicable in terms of informing clinical practice and creating guidelines for the reliable assessment of fitness to drive
To drive or not to drive? Understanding the influence of the complex relationships between personal and environmental factors on the driving mobility and social participation of older Canadians	Vrkljan	2016/17	aims to provide the most up-to-date and in-depth understanding of factors that can influence transportation mobility in older adulthood and how these relationships impact social participation.
Medically at-risk drivers: The road to developing evidence-based fitness to drive guidelines	Crizzle	2018/19 to 2021/22	the development of an online, web-based repository (e-repository) where data from comprehensive driving evaluations of medically at-risk drivers are captured and tracked accordingly. this data will be used to examine the referral process and the relationship between functional abilities, on-road driving performance

Appendix V Department for Transport Commissioned Research on Driving Fitness: Road Safety Research Reports (RSRRs) 2001 - 2010

Study Title	**DfT Theme (theme number)**	**Year of publication**	**DfT RSRR or RSWP Report No.**
The Role of Risk Analysis in the Evaluation of Fitness to Drive	Medical aspects of fitness to drive (6)	2003	40
Risk Analysis and Fitness to Drive: An Evaluation of Sensitivity Issues	Medical aspects of fitness to drive (6)	2003	41
Medical Aspects of Excessive Daytime Sleepiness: A consensus workshop	Medical aspects of fitness to drive (6)	2004	45
An Approach to measuring the Visual Field Component of Fitness to Drive	Medical aspects of fitness to drive (6)	2004	49
Risk of acute vascular events following initial myocardial infarction or stroke	Medical aspects of fitness to drive (6)	2005	65
Expert Consensus Workshop: Driving Safety and Cardiac Ischaemia, 7-8 July 2005	Medical aspects of fitness to drive (6)	2005	67
Stratifying Hypoglycaemic Event Risk in Insulin Treated Diabetes	Medical aspects of fitness to drive (6)	2006	61
Expert Consensus Workshop: Diabetic Retinopathy and Fitness to Drive	Medical aspects of fitness to drive (6)	2006	72
Central Scotomata and Driving	Medical aspects of fitness to drive (6)	2008	79
Systematic review of the probability of future seizures after initial seizure or other event creating an increased future risk	Medical aspects of fitness to drive (6)	2010	RSWP 5
The Attitudes of Health Professionals to Giving Advice on Fitness to Drive	Medical aspects of fitness to drive (6)	2010	91
The Role of Carbohydrate Deficient Transferrin as an Alternative to Gamma Glutamyl Transferase as a Biomarker of Continuous Drinking: A Literature Review	Medical aspects of fitness to drive (6)	2010	103
The Role of Carbohydrate Deficient Transferrin as an Alternative to Gamma Glutamyl Transferase as a Marker of Continuous Drinking in High-Risk Drivers	Medical aspects of fitness to drive (6)	2010	104
Expert Consensus Workshop: Driving Safety and Vascular Disease	Medical aspects of fitness to drive (6)	2010	106
Analysis of Risk Outcomes for Cardiac Conditions	Medical aspects of fitness to drive (6)	2010	107
Vision and driving	Impairment (3)	2000	2
Cannabis and driving: a review of the literature and commentary	Impairment (3)	2001	12
Older drivers: a literature review	Impairment (3)	2001	25

Forecasting older driver accidents and casualties	Impairment (3)	2001	23
Sleep-related vehicle accidents	Impairment (3)	2001	22
Driver sleepiness	Impairment (3)	2001	21
Alcohol and pedestrians	Impairment (3)	2001	20
The ageing driver: A programme of research	Impairment (3)	2002	29
Anti-depressants and road safety: a literature review and commentary	Impairment (3)	2003	18
Older drivers: illness and medication	Impairment (3)	2003	39
Older drivers: a literature review (presumably an update of the 2001 report)	Impairment (3)	2003	28
Over-the-counter medicines and the potential for unwanted sleepiness	Impairment (3)	2004	24
Sleep-related crashes on sections of different road types in the UK (1995-2001)	Impairment (3)	2004	52
Evaluation of the effectiveness of the National Driver Improvement Scheme	Impairment (3)	2005	64
Effectiveness of MSAs in reducing fatigue related and other accidents	Impairment (3)	2006	57
Interactions between sleepiness and moderate alcohol intake in drivers	Impairment (3)	2006	62
Monitoring the effectiveness of the UK field impairment tests	Impairment (3)	2006	63
Intervention modalities to address psychosocial predictors of driving behaviour among adolescents	Impairment (3)	2007	70
An investigation of the usefulness, the acceptability and impact on lifestyle of alcohol ignition interlocks in drink driving offenders	Impairment (3)	2008	88
A review of international evidence on the use of alcohol ignition interlocks in drink drive offences	Impairment (3)	2008	89
A review of methodologies employed in roadside surveys of drinking and driving findings	Impairment (3)	2008	90
Fatigue Risk Management Systems: A Review of the Literature	Impairment (3)	2010	110
A qualitative study of drinking and driving: Report on the literature review	Impairment (3)	2010	113
A qualitative study of drinking and driving: Report on the findings	Impairment (3)	2010	114
Medication and road safety: A scoping study	Impairment (3)	2010	116
Interviews with Operators, Regulators and Researchers with Experience of Implementing Fatigue Risk Management	Impairment (3)	2010	120
Review of Effectiveness of Laws Limiting Blood Alcohol Concentration Levels to Reduce	Impairment (3)	2010	none given

Alcohol-related Road Injuries and Deaths - NICE review of BAC and road safety findings			
Guidance for Drink-Drive Rehabilitation (DDR) Training Providers	Impairment (3)	2010	RSWP 12
Professional Skills for Delivering the Drink-Drive Rehabilitation (DDR) Scheme: Analysis of DDR Training Provider Organisations Interview findings	Impairment (3)	2010	ESWP 13
Professional Skills for Delivering the Drink-Drive Rehabilitation (DDR) Scheme: Summary of Project Deliverables, Detailed Improvement Plans and Next Steps	Impairment (3)	2010	RSWP 14
The relationship between blood alcohol concentration (BAC) and breath alcohol concentration (BrAC): a review of the evidence	Impairment (3)	2010	RSWP 15
Fatigue and Road Safety: a critical analysis of recent evidence	Impairment (3)	2011	RSWP 21

Appendix VI Transport Research Laboratory (TRL) Reports of studies on Driving Fitness

TRL Publications on Fitness to Drive: 2000 to 2022

Title	First Author	Date Published	Brief Summary
The influence of cannabis and alcohol on driving	Sexton, B.	2002	Study of the influence of different doses of cannabis and alcohol on driving and driving related skills are reported. Male drivers who were regular cannabis and alcohol users undertook a variety of different tasks.
Returning to driving following a head injury or amputation: results of a drivers' survey	Smith, L.	2005	The project investigated drivers' experiences following either a traumatic head injury and a limb amputation.
The validity and reliability of the Stroke Drivers Screening Assessment	Sentinella, J.	2005	To investigate the current use of the Stroke Drivers Screening Assessment in the UK and examine the validity and reliability of the screening tool.
Data gathering on disability and driving statistics stage 2	Tong, S.	2008	Gathers existing data on disabled drivers and enhances the value of such datasets by surveying subsets of the recorded populations. Analysis and comparison of these data sources has created a number of statistics relating to disabled drive.
The relationship between driver fatigue and rules limiting hours of driving and work	Parkes, A.	2009	The aims of this project were to review existing UK and international research and other published material in order to determine any links that exist between long driving or working hours and driver fatigue, and the extent to which limits on hours of driving or work help to prevent fatigue related accidents for drivers.
Drivers attitudes to distraction and other motorists behaviour A focus group and observational study	Diels, C.	2009	This study was designed to investigate two hypotheses about typical driving behaviours: (1) the majority of motorists engage in behaviours that could be considered unsafe, on a daily basis, and (2) that these unsafe behaviours may be, at least partly, due to social pressure.
Road safety priorities for high risk groups in Northern Ireland	Charman, S.	2012	This report has been produced in order to support a review of the Road Safety Education Officer Service (RSEOS) in Northern Ireland. The report provides a review of

			documentation and published data alongside new analyses of collision data in order to clearly identify what should be the priorities for the RSEOS going forward.
Why do older drivers have more 'failed to look' crashes? A simulator based study	Reed, N.	2012	This study aimed to investigate the correlation between failed to look errors, which previous studies have identified as a key factor in crashes involving older drivers, and visuo-cognitive deficits.
Study on driver training, testing and medical fitness	TRL	2016	Improving the education and training of road users in Europe through a range of training, testing and licensing approaches is an important strategic objective of the Commission's "Policy Orientations on road safety 2011-2020". Another is the protection of vulnerable road users, especially motorcyclists and also older drivers.
Further analyses of driver licence records from DVLA	Broughton, B.	2018	This report investigates the distribution of driving offences in Great Britain by analysing data from an archive of licensing information that was set up at TRL, the original information coming from the DVLA's Driver Licence file.
Novice drivers - evidence review and evaluation	Kinnear, N.	2018	Based on the evidence, it is recommended that licensing in GB be based on a full Graduated Driver Licensing (GDL) system. Analysis of STATS19 data and evidence of effectiveness in other countries suggests that a GDL system in GB could save 4,471 casualties and £224 million annually based on 17-19 year old drivers only.
Novel methods to measure risk calibration in the older driver	Lang, B.	2018	This reinvestment study aimed to shed light on a process which is often confidently described as being effective in limiting older drivers collision involvement, but which we actually only poorly understand. It posed the question how far a lack of calibration is not only a problem for young, but older drivers and can inform the development of interventions that may improve older drivers calibration, for example, through training.
The forgotten risk of driving with hypoglycaemia in type 2 diabetes	Parkes, A.	2018	Almost 1 in 4 driving licences with a medical notification has a notification related to treatment for diabetes. In 2014, this was

			equivalent to approximately 575,000 active licences for people treated with diabetes, of which 13% were Group 2 drivers (typically of lorries and/or buses).
Graduated driver licensing in the Isle of Man	Kinnear, N.	2020	A review of evidence for the most effective interventions to improve the safety of young and novice drivers in the Isle of Man recommended the implementation of graduated driver licensing (GDL) (Kinnear, Sharpe & Hitchings, 2019). This document considers how GDL could be implemented in the Isle of Man.
Alcohol and drugs in road fatalities	Ramnath, R.	2021	This report covers data for fatal road collisions that occurred in 2019 and contains an overview of the data collection method, a summary of the BAC and drug data collected, and the results of more detailed BAC analysis.