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Issues relating to the efficacy of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions by medical and other health practitioners

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1. Introduction

Road trauma remains a significant public health and safety concern globally (World Health Organization, 2015). While many factors contribute to road trauma, the increasing prevalence of chronic medical conditions and the ageing of the driving population (Koppel and Berecki-Gisolf, 2015), has resulted in the issue of a driver's medical 'fitness to drive' becoming an important consideration (Koppel et al., 2018). Despite being an 'everyday' task, driving requires the simultaneous execution of cognitive, physical, psychomotor, and sensory skills, and is influenced by a driver's arousal, attention, auditory functions, concentration, decision making, emotions, learning skills, perception, memory, reflex speed, time estimation, and visual functions (Groeger, 2013). Driving is arguably one of the riskiest daily living tasks undertaken in an often unpredictable environment under strict time pressures with potentially catastrophic consequences of errors impacting on the driver and other road users (Di Stefano and Macdonald, 2010). Chronic medical conditions and treatments, as well as age-related functional declines, may adversely affect the skills, processes and requirements necessary for safe driving (Charlton et al., 2010; Marshall, 2008; Vaa, 2003). Consequently, it is critical that drivers who hold a driver's licence are medically and functionally fit and safe to operate a motor vehicle, and that licensing decisions take into account possible functional impairments and/or treatments associated with chronic medical conditions and/or age-related declines (Marshall, 2008).

One approach aimed at reducing road trauma is the mandated reporting of medically unfit/unsafe drivers by medical and other health practitioners to licensing authorities (Jones et al., 2012; Redelmeier et al., 2008; Sims et al., 2012). A number of jurisdictions have implemented legislation requiring mandatory medical reporting – impacting both medical and other health practitioners (Langford et al., 2010; White and O'Neill, 2000).

Mandatory medical reporting targets drivers with a chronic, long-term medical condition(s) or disability(ies), as opposed to a temporary condition(s) (Austroads, 2016), which would likely result in functional impairments (either due to the medical/disability condition itself or its treatment) and increases their risk of being involved in a motor vehicle crash. However, the specific requirements for reporting by medical and other health practitioners are variable across different licensing authorities. In Australia, the Assessing Fitness to Drive Guidelines (Austroads, 2016) are utilised by medical and other health practitioners to determine whether or not a patient is fit to drive dependent upon their functional status. However, South Australia and the Northern Territory, physicians are mandated to report the patient to the relevant driver licensing authority if they are suffering from a physical or mental illness, disability or deficiency such that, if they patient drove a motor vehicle, they would be likely to endanger the public. Similarly,

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mandatory medical reporting of unfit drivers is required by Canadian physicians in all provinces except Alberta, Nova Scotia and Quebec, and is determined by a physician's diagnosis of a person's ability to drive a vehicle safely with regard to the safety of the public. However, differences exist regarding the reporting requirements between Canadian provinces. For example, physicians in the provinces of British Columbia and Manitoba are only required to report patients if they have been warned and still continue to drive (Canadian Medical Association, 2018).

Advocates of mandatory medical reporting argue that the law takes the onus away from the individual driver to report their medical condition(s) and/or functional impairments to licensing authorities and places the responsibility onto medical and other health practitioners who are best placed to objectively assess a patient's medical fitness to drive (Langford et al., 2010). However, critics of mandatory medical reporting argue that medical and other health practitioners are often reluctant to report their patients to licensing authorities due to: uncertainty over what constitutes an 'unfit'/'unsafe' driver or 'significant' functional impairment; worries about patient dissatisfaction; limited time; a lack of training or appropriate screening or assessment tools, and the view that road safety/road trauma is not a medical/health problem that merits preventive efforts by medical or other health practitioners (Jones et al., 2012; Langford et al., 2010; Redelmeier et al., 2008; Sims et al., 2012). In addition, critics of mandatory medical reporting also argue that the current evidence for causal relationships between specific medical conditions and increased motor vehicle crash risk is limited (Charlton et al., 2010; Dobbs, 2001; Marshall, 2008; Vaa, 2003). Indeed, not all medical conditions affect motor vehicle crash risk to the same extent, and not all individuals/drivers with the same medical condition will be affected in the same way (Charlton et al., 2010). It is not necessarily the medical condition and/or treatments *per se* that affects motor vehicle crash risk, but rather the *functional impairments* that may be associated with the medical condition(s) and/or the associated treatment (Charlton et al., 2010). In addition, the extent to which individuals may be able to adapt or compensate for their functional impairment whilst planning for and actually driving will have some bearing on their likelihood of motor vehicle crash involvement, at least for drivers with intact insight (Charlton et al., 2010; Dobbs, 2001; Marshall, 2008; Vaa, 2003).

Few studies have evaluated the efficacy of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions by medical and other health practitioners in terms of increasing the number of medically unfit/unsafe drivers reported to licensing authorities or decreasing the number of motor vehicle crashes due to medically unfit/unsafe drivers. Mandatory medical reporting by medical and other health practitioners may also have adverse public health implications which affect the patient-physician relationship, as well as patient / driver and public safety (Byszewski et al., 2010; Chan et al., 2013; Jones et al., 2012). For example, drivers with a medical condition(s) may avoid seeking treatment from their health professional due to their fear of being reported to the licensing authority, thus further jeopardising their health (Jones et al., 2012; Langford et al., 2010; Redelmeier et al., 2008; Sims et al., 2012).

1.1. Objectives

The current study systematically reviewed the available literature to synthesise evidence on key issues relating to the efficacy of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions by medical and other health practitioners. Specifically, the current study aimed to answer the following three research questions:

1. What is the effectiveness of mandatory medical reporting by medical and other health practitioners for increasing reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities?
2. What is the effectiveness of mandatory medical reporting by medical and other health practitioners for reducing crash risk for drivers with medical and other fitness to drive relevant conditions?
3. What are the public health implications of mandatory medical reporting by medical and other health practitioners of drivers with medical and other fitness to drive relevant conditions?

2. Methods

2.1. Protocol and registration

The systematic review was conducted in accordance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Liberati et al., 2009; Moher et al., 2009) which provides a detailed guide on the conduct and reporting style for systematic reviews and meta-analyses. The protocol for this systematic review was registered with PROSPERO in June 2018 CRD420180962714.

2.2. Eligibility criteria

2.2.1. Inclusion criteria

Studies were included in the systematic review according to the following a priori criteria: i) original research in a peer-reviewed journal; ii) full-text available; iii) published in English language and human studies; iv) used quantitative and/or qualitative methods for data collection and analysis, and v) examined mandatory medical reporting of medical conditions or disabilities to licensing authorities by medical or other health practitioners, including studies that examined:

- Frequency of referrals of drivers with medical and other fitness to drive relevant conditions to licensing authorities;

- Crash risk for drivers with medical and other fitness to drive relevant conditions where motor vehicle crash risk was assessed by the frequency of crashes or near-crashes involving motor vehicles that resulted in an injury or fatality (World Health Organization, 2016), as identified by self-report or official crash records, and
- Public health and other implications for drivers with medical and other fitness to drive relevant conditions including mortality/morbidity, mobility, isolation, contact with medical and other health practitioners, and psychological and social health. Other implications included those relating to the parties with the obligations to report (i.e., health practitioners) and others (e.g., carers, family members, police, community, state governments, etc.).

For the purposes of this systematic review, mandatory medical reporting was defined as mandatory reporting of driver's medical conditions or disabilities to licensing authorities by medical (e.g., general practitioners [GPs], geriatricians, neurologists, cardiologists, etc.) and other health practitioners (e.g., optometrists, occupational therapists, etc.). Reporting was within the context of drivers who are unfit/unsafe to drive or suspected of being unfit/unsafe to drive. The criteria and guidelines used to report medically unfit/unsafe drivers varied between jurisdictions (Langford et al., 2010). The key question when assessing medical fitness to drive was whether there is a likelihood the individual will be able to control the vehicle and respond appropriately to the driving environment in a safe, consistent and timely manner. Medical conditions were usually long-term medical conditions which are associated with functional impairments (e.g., sensory, cognitive, physical, or psychomotor functions) that may affect the skills required for safe driving. It did not apply to reporting of all drivers with all types of medical conditions. Examples of medical conditions that may cause impairments to driving ability included: neurological conditions (e.g., dementia, epilepsy, stroke, multiple sclerosis), psychiatric conditions, alcohol abuse and dependence, etc. (Charlton et al., 2010; Marshall, 2008; Vaa, 2003). Reporting by all medical and other health practitioners were included in scope.

2.2.2. Exclusion criteria

Studies were excluded from the systematic review according to the following a priori criteria: i) commentary manuscripts; ii) literature reviews; iii) dissertations; and iv) studies which did not investigate mandatory medical reporting of medical conditions or disabilities to licensing authorities by medical or other health practitioners.

2.3. Information sources

Relevant studies were identified before the development of a search strategy and were defined as ‘goldset studies’. These goldset studies were then used to help identify relevant search terms. An electronic search of databases from the disciplines of public health, psychology and transport safety (Ovid Cochrane Library, Ovid Medline, Ovid PsycINFO, Ovid EMBASE, CINAHL PLUS, Ovid TRANSPORT and TRID: TRIS and ITRD database) was conducted on May 28th 2018 to locate studies from the first available year to May 2018. In addition, a bibliographic review of included studies and a review of goldset studies was conducted to locate additional studies. Leading researchers in the field of licensing, assessing fitness to drive and road safety were also contacted to identify further relevant studies.

2.4. Search

Two key concepts were derived: 1) Drivers/Driving; and 2) Mandatory Reporting. Search terms (both indexed [e.g., Medical Subject Headings] and key words) associated with both concepts were derived independently from each author and in consultation with a subject matter expert librarian (Table 1).

2.5. Study selection

Search results were exported into Endnote X8 software and duplicates were removed from the total number of identified records using a standard function. The final list of studies was exported into Covidence (Cochrane technology platform). Two researchers (SK, PH) independently completed an initial screening of titles and abstracts for eligibility and a priori inclusion and exclusion criteria were applied. Following title and abstract screening, the two reviewers (SK, PH) independently applied inclusion and exclusion criteria to the full-texts of the remaining records to select studies for this review. A bibliographic review of included studies, as well as a review of goldset studies, was conducted to identify additional relevant studies. Any conflicts between the two reviewers were resolved by a third reviewer (LB).

2.6. Data collection process

A full-text review of each included study was conducted by three reviewers (SK, LB, PH) and the following data items were extracted into a pretested data extraction sheet: authors; date of publication; research design; study aim; study period; study location and population; participant demographics, including specific medical or other fitness to drive condition(s); data sources and analysis; outcomes, including legislation/program related to mandatory medical reporting; research findings, and risk of bias assessment (see Section 2.7).

Table 1
Search strategy.

Database: Ovid MEDLINE(R) 1946 to Present with Daily Updates May 28, 2018 Search strategy:

1. Automobile Driving/
2. (automobil* adj1 driv*).tw.
3. (vehicle* adj1 driv*).tw.
4. (car* adj1 driv*).tw.
5. (driv* adj1 behavio?r*).tw.
6. Automobile Driver Examination/
7. (driv* adj1 examination*).tw.
8. (driv* adj1 assess*).tw.
9. (driv* adj1 reassess*).tw.
10. (medical adj1 assess*).tw.
11. (medical adj1 warning*).tw.
12. (mandat* adj1 medical).tw.
13. (mandat* adj1 report*).tw.
14. (physician* adj1 report*).tw.
15. (medical adj1 report*).tw.
16. (fitness adj2 driv*).tw.
17. (unfit adj2 driv*).tw.
18. (driv* adj2 medical).tw.
19. (driv* adj2 health*).tw.
20. Mandatory Reporting/
21. 1 or 2 or 3 or 4 or 5
22. 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20
23. 21 and 22

2.7. Risk of bias in individual studies

2.7.1. Risk of bias for quantitative studies

The risk of bias for quantitative studies was assessed independently by two reviewers (SK, PH) using the National Heart, Lung and Blood Institute Quality Assessment tools (National Heart Lung and Blood Institute, 2014). Each reviewer completed a table (based on 12 criteria for case-control studies and 14 criteria for observational cohort and cross-sectional studies) and assessed each study for: risk of potential for selection bias, information bias, measurement bias or confounding factors. Based on this assessment, the two reviewers independently gave each quantitative study a total score (out of 12 or 14 respectively) and provided an overall quality rating ('good', 'fair' or 'poor'), where the greater the risk of bias, the lower the quality rating of the study. Any discrepancies between the two reviewers were resolved by a third reviewer (LB).

2.7.2. Risk of bias for qualitative studies

The risk of bias for qualitative studies was assessed independently by two reviewers (LB, PH) using the COnsolidated criteria for REporting Qualitative research tool (COREQ) (Tong et al., 2007). A table was designed based on the COREQ checklist for explicit and comprehensive reporting of qualitative studies, which includes 32 criteria and a descriptor that corresponded with each item. All items were grouped into three domains: (i) research team and reflexivity, (ii) study design, and (iii) data analysis and reporting. The first domain referred to personal characteristics of the qualitative researchers and their relationship with participants. The second domain related to the theoretical framework, participant selection and setting and data collection processes of the study. The third domain referred to the characteristics of data analysis and reporting. Based on this assessment, each qualitative study was given a total score (out of 32). Any discrepancies between the two reviewers were resolved by a third reviewer (SK).

3. Results

3.1. Study selection

The systematic review process from identification to inclusion of studies is summarised in Fig. 1 using the PRISMA flow chart. The combined searches identified 3436 studies and 27 duplicates were then removed. Following title and abstract screening, 166 studies were identified for full-text review and 123 studies were excluded for the following reasons: 52 were identified as the wrong publication type (reports, dissertations, commentaries or reviews), eight studies assessed the wrong outcomes, four were not available in English language, seven were duplicates, and 52 did not have a full-text available. Altogether, 43 studies met the inclusion criteria. A review of the goldset studies yielded seven additional studies. All 50 studies (quantitative studies: n = 45, qualitative studies: n = 5) were assessed – a summary of which is provided in Supplementary Table S1 and Table 4 (quantitative studies, qualitative studies, respectively).

3.2. Study characteristics

Included studies were published between 1992 and 2018. Of the 50 studies, 45 were quantitative studies and five were qualitative

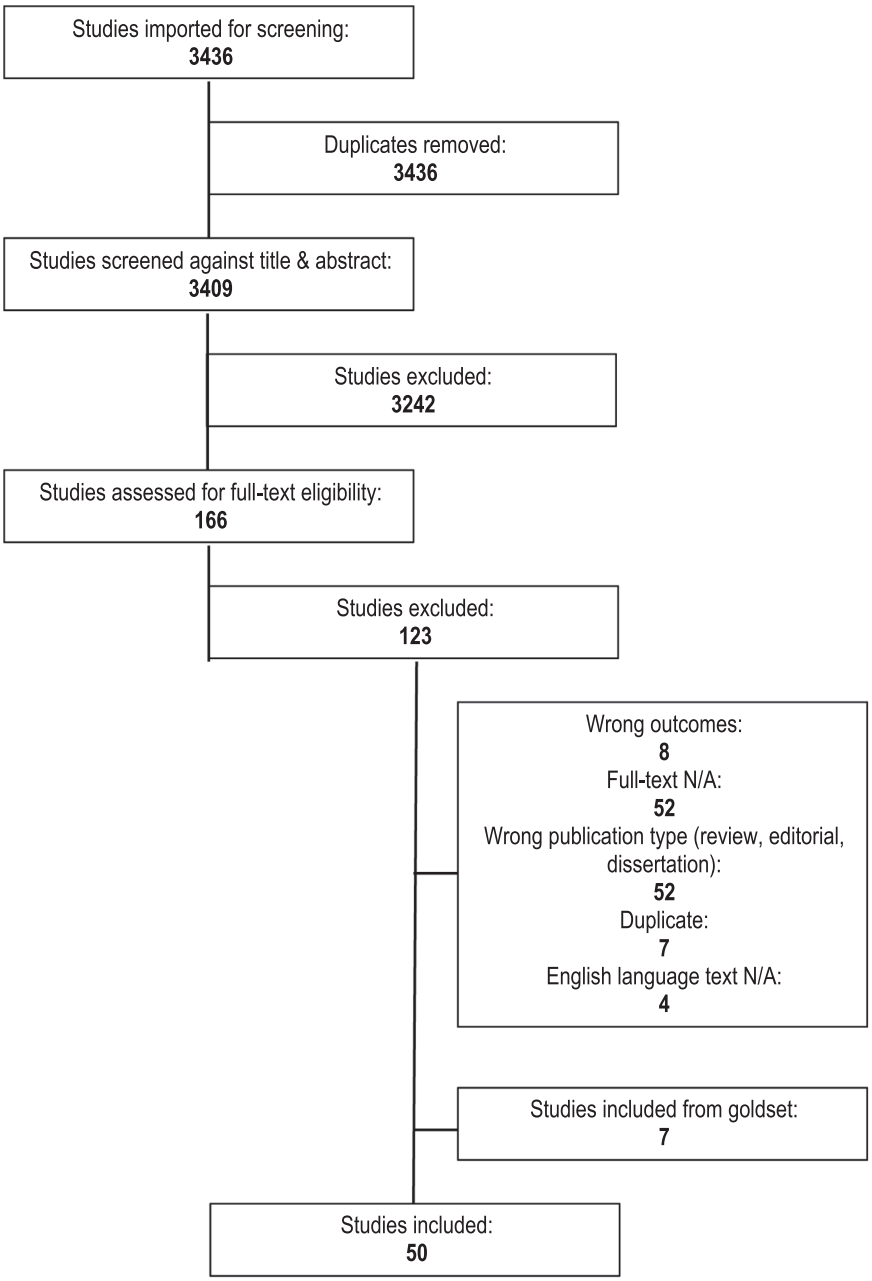

Fig. 1. PRISMA guidance flow diagram of identification, screening, and inclusion of eligible studies.

studies. Of the quantitative studies, two were case-control studies and 43 were cross-sectional studies. Of the cross-sectional studies, eight were experimental studies and 35 were retrospective self-report/face-to-face surveys. Of the qualitative studies, two used semi-structured interviews, two studies used focus group methodology and one used both semi-structured interviews and focus group methodology. Details of each of the included studies are summarised in Supplementary Table S1 and Table 4.

Study sample sizes ranged from 15 – 174,066 (quantitative studies: Range = 23–174,066; qualitative studies: Range = 15–91). The mean age of participants across all studies was 52.5 years (Range = 14.0 – 92.0 years). The mean age for medical and other health practitioner participants was 46.0 years (Range = 28–82 years) and the mean age for driver or patient participants (e.g., drivers and /or individuals with medical conditions [e.g., dementia, epilepsy] with and without driver's licences) was 51.89 years (Range = 14.0–92.0 years). The mean proportion of male participants across all studies was 60.88% (Range = 33.3–90.0%). The mean proportion of male medical and other health practitioners was 68.6% (Range = 45.0–84.0%) and for driver or patient participants was 54.5% (Range = 33.3–87.0%).

As noted in Supplementary Table S1 and Table 4, studies included a diverse range of participant populations, including: drivers

(n = 3), drivers admitted to hospital following a motor vehicle crash (n = 2), drivers or patients who had received a warning or reported to the licensing authority by medical and other health practitioners or with cancelled licences (n = 3), drivers or patients with dementia (n = 2), drivers or patients with dementia who were told to cease driving and their caregivers (n = 1), drivers or patients with epilepsy or seizures (n = 4) (Drazkowski, et al., 2010; McLachlan et al., 2007; Salinsky, et al., 1992; Tatum et al., 2012) drivers or patients with multiple sclerosis (n = 1), attendees of the Australian College of Legal Medicine (n = 1), law enforcement officers or licensing authorities (n = 1) and medical and other health practitioners, including: cardiologists, emergency physicians, endocrinologists, family physicians, general practitioners (GPs), general surgeons, geriatric medicine, internal medicine, neurologists, neurosurgeons, orthopaedic surgery, physical medicine, primary care physicians, psychiatrists (n = 2), radiation oncologists, rehabilitation specialists and sleep/electro physicians (n = 28). Studies were also conducted in various countries including the U.S. (n = 19), Canada (n = 11), Australia (n = 10), U.K. (n = 4), Switzerland (n = 2), Ireland (n = 2), Sweden (n = 1), and Saudi Arabia (n = 1).

3.3. Risk of bias within studies

3.3.1. Quantitative studies

Quantitative studies were assessed for risk of bias (see Table 2). The two case-control studies were scored out of 12 and were provided with an overall quality rating ('good', 'fair' or 'poor') (National Heart Lung and Blood Institute, 2014). The mean score for the two studies was 7.00 or an average 'fair' rating (Range = 7.00). The 43 cross-sectional studies were scored out of 14 and were also provided an overall quality rating ('good', 'fair' or 'poor') (National Heart Lung and Blood Institute, 2014). The mean score for the 43 studies was 6.91 or an average 'fair' rating (Range = 6.00–9.00). Nine studies were rated as 'good' (i.e., a score of 8 or 9) and 34 studies were rated as 'fair' (i.e., a score of 6 or 7).

3.3.2. Qualitative studies

Qualitative studies were also assessed for risk of bias and given a score out of 32 (Tong et al., 2007)[1] (see Table 3). The mean score for the five studies was 15.40 (Range = 13.00–17.00), representing a moderate level of risk of bias.

3.3.3. Effectiveness of mandatory medical reporting by medical and other health practitioners for increasing reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities

The review identified seven studies that examined the effectiveness of mandatory medical reporting by medical and other health practitioners for increasing reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities (Cable et al., 2000; Elgar and Smith, 2018; Jang et al., 2007; Louie et al., 2012; Marshall et al., 2012; McLachlan and Jones, 1997; Redelmeier et al., 2008).

Two of the seven studies concluded that mandatory medical reporting laws do not increase reporting of drivers with medical and other fitness to drive relevant conditions by medical and other health practitioners to licensing authorities. For example, Redelmeier and colleagues (Redelmeier et al., 2008) examined the consecutive records of 1,605 drivers admitted to a hospital following a motor vehicle crash in a jurisdiction with mandatory medical reporting laws (Ontario, Canada[2]) to determine how many crash-involved drivers had previously been seen and reported by a physician. They reported that 37 percent of crash-involved drivers had a reportable medical condition and that 85 percent of these drivers had seen a medical or other health practitioner within the year before their motor vehicle crash. However, they noted that only three percent of these drivers had been reported by their medical or other health practitioner to the licensing authority. Interestingly, the authors noted that the frequency of reporting for drivers with a reportable medical condition was only marginally higher than the baseline frequency for reporting drivers without a reportable medical condition (3% vs. 1%). The authors noted that the non-zero baseline frequency was explained by routine reporting of drivers with commercial licenses (for whom mandatory medical reports must be filed). As noted in Table 2, the quality of the evidence described in this study was rated 'fair'.

Cable and colleagues also examined the effectiveness of mandatory medical reporting laws for increasing reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities (Cable et al., 2000). The authors surveyed U.S. geriatricians' knowledge, attitudes and practices regarding patients with dementia who are potentially dangerous drivers across geriatricians in California, which has mandatory medical reporting laws (n = 82), and geriatricians from other U.S. states without mandatory medical reporting laws (n = 385). Based on the self-reported survey, 75.5 percent of geriatricians agreed that they are responsible for reporting their patients with dementia who drive and who are potentially dangerous to licensing authorities – however there was no significant difference between geriatricians in jurisdictions with mandatory medical reporting (79.3%) and geriatricians in jurisdictions without mandatory medical reporting (74.8%). Approximately one quarter of geriatricians (28.5%) also self-reported that they do not know how to report these patients to licensing authorities – however, geriatricians in jurisdictions without mandatory medical reporting were significantly more likely to be unsure of how to report their patients (31.8%) compared to geriatricians in jurisdictions with mandatory medical reporting laws (9.8%). In addition, most geriatricians reported that they would contact the licensing authority if they were concerned about their patient, despite the objections of their patient (86.4%) or their

[1] Note: These scores do not translate to a category score (i.e., good/fair/poor).

[2] Note: Ontario has broad laws mandating physicians report any patient who is suffering from a medical condition that may make it dangerous for them to operate a motor vehicle.

Table 2
Ratings of risk of bias within quantitative studies (n = 45).

Type of study	Score	Rating	Studies
Case-control studies	7	Fair	(Drazkowski et al., 2010; McLachlan et al., 2007)
Cross-sectional studies	9	Good	(Jang et al., 2007)
	8	Good	(Agimi, Albert, Youk, Documet, and Steiner, 2017; Batool, Roberts, Kalra, and Manawadu, 2014; Cable, Reisner, Gerges, and Thirumavalavan, 2000; Louie et al., 2012; Lovas et al., 2016; Marshall, Demmings, Woolnough, Salim, and Man-Son-Hing, 2012; Ménard et al., 2006; Redelmeier, Yarnell, Thiruchelvam, and Tibshirani, 2012)
	7	Fair	(Adler and Rottunda, 2011; Alkharboush et al., 2017; Baker and Rogers, 2005; Beran, Ainley, and Beran, 2007; Black and Lai, 1997; Drickamer and Marottoli, 1993; Eggert, Thali, and Pfäffli, 2012; Elgar and Smith, 2018; Gergerich, 2015; Gillespie and McMurdo, 1999; Marshall and Gilbert, 1999; McLachlan and Jones, 1997; McManus et al., 2005; Ng et al., 2015; Omer, Dolan, Dimitrov, Langan, and McCarthy, 2014; Redelmeier et al., 2008; Salinsky et al., 1992; Snellgrove and Hecker, 2002; Snyder and Ganzini, 2009; Turnipseed et al., 2008)
	6	Fair	(Beran, 1998; Brooks et al., 2011; Chan et al., 2013; Chang, Astrachan, Weil, and Bryant, 1992; Elgar, Esterman, Antic, and Smith, 2016; Kahvedžić, Mcfadden, Cummins, Carr, and O'Neill, 2015; McGwin et al., 2003; Miller and Morley, 1993; Pfäffli, Thali, and Eggert, 2012; Shanahan, Sladek, and Phillips, 2007; Sims et al., 2012; Tatum et al., 2012; Vogtle, 2007)

Table 3
Risk of bias for qualitative studies (n = 5[a]).

Type of study	Score	Studies
Semi-structured interviews	17	(Adler and Rottunda, 2010; Byszewski et al., 2010)
Semi-structured interviews & focus groups	16	(Jones et al., 2012)
	15	N/A
Focus groups	14	(Archer, Morris, and George, 2014)
	13	(Bogner, Straton, Gallo, Rebok, and Keyl, 2004)

[a] Note: One study included both semi-structured interviews and focus group methodology (Jones et al., 2012).

patient's family (72.9%) – however there was no difference between geriatricians in jurisdictions with and without mandatory medical reporting (Cable et al., 2000). As noted in Table 2, the quality of the evidence described in this study was rated 'good'. Most recently, Elgar and Smith (Elgar and Smith, 2018) surveyed 35 sleep and electro-physicians in the state of South Australia (Australia) - which has mandatory medical reporting laws – and only 11.8 percent reported 'all' reportable patients, 14.7 percent had 'never' reported patients, and 73.5 percent inconsistently reported their reportable patients. As noted in Table 2, the quality of the evidence described in this study was rated 'fair'.

However, four of the seven studies reported that medical and other health practitioners within licensing jurisdictions with mandatory medical reporting laws are significantly more likely to report potentially unfit/unsafe drivers to the licensing authority than medical and other health practitioners in jurisdictions without mandatory medical reporting laws (i.e., discretionary or voluntary reporting laws) (Jang et al., 2007; Louie et al., 2012; Marshall et al., 2012; McLachlan and Jones, 1997). For example, Jang and colleagues conducted a survey on attitudes and practices towards driving assessments and reporting of medically unsafe drivers with 460 Canadian family physicians from provinces with mandatory medical reporting laws and discretionary reporting requirements. They reported that physicians from provinces with mandatory medical reporting laws were significantly more likely to report unsafe drivers (OR = 2.78; 95% CI: 1.58–4.91) than physicians from provinces with discretionary reporting requirements. However, the authors did note that physicians from provinces with mandatory medical reporting laws were significantly less likely to perform driving assessments (OR = 0.58; 95% CI: 0.39–0.85). Similarly, Marshall and colleagues assessed the attitudes and practices of 842 Canadian physicians and specialists regarding assessing fitness to drive in older patients and found that physicians/specialists in licensing jurisdictions with mandatory medical reporting laws were significantly more likely to report their patients whom they consider unsafe to drive (67%) or whose ability to drive safely is questionable (63%) than physicians/specialists in licensing jurisdictions without mandatory medical reporting laws (41%, 49%, respectively) (Marshall et al., 2012). In addition, Marshall and colleagues also noted that medical practitioner speciality may also be significantly associated with increased reporting. For example, they noted that geriatricians were significantly more likely than neurologists to report drivers with mild Alzheimer's disease to the licensing authority – regardless of mandatory medical reporting laws. As noted in Table 2, the quality of evidence described in these four studies was rated 'good'.

3.3.4. Effectiveness of mandatory medical reporting by medical and other health practitioners for reducing crash risk for drivers with medical and other fitness to drive relevant conditions?

The review identified three studies that investigated the effectiveness of mandatory medical reporting by medical and other health practitioners for reducing crash risk for drivers with medical and other fitness to drive relevant conditions, where crash risk was defined as the frequency of crashes or near-crashes involving motor vehicles that resulted in an injury or fatality (World Health Organization, 2016).

Two of the three studies concluded that mandatory medical reporting does not reduce crash risk (Agimi et al., 2017; McLachlan

Table 4
Summary characteristics and quality assessments of qualitative studies.

Study	Study design	Comparison group	Intervention group	Study period	Study setting-country	Study population	*N* (participants)	Gender (%)	*M* age (range)	Outcome measures	Summary of key findings	COREQ score
(Adler and Rottunda, 2010)	Semi-structured interviews	No	No	NR	U.S.	Older drivers, law enforcement officers, & licensing authorities	Total: 91	Older drivers: Male = 49.0%	Older drivers: Mean age = 74.2 years (SD = 8.9, Range = 60-92)	Attitudes, beliefs, & preferences of older adults, law enforcement officers, & DLA re: fitness to drive for persons with Alzheimer's disease & Parkinson's disease	All supported reassessment drivers with Alzheimer's disease	17
							Older drivers: 52	Law enforcement officers: Male = 90.0%	Law enforcement officers: Mean age = 45.1 years (SD = 6.9; Range = NR)		Moderate support for reassessment of 90-year-olds & those with Parkinson's disease	
							Law enforcement officers: 19	DLA: Male = 75.0%	DLA: Mean age = 51.1 years (SD = 7.4; Range = NR)		Least support for reassessment of 70-year-old drivers	
							DLA: 20				More education needed re: legal & ethical responsibilities to address unsafe driving	
(Archer et al., 2014)	Focus groups	No	No	NR	Australia	Individuals with multiple sclerosis: 1) currently driving; 2) no longer licenced/ driving	Total: 17	Individuals with multiple sclerosis currently driving: Male = 40%	Individuals with multiple sclerosis currently driving: Mean age = 44.2 years (SD = 13.2; Range = 18-65)	Experiences & needs of individuals with multiple sclerosis re: driver assessment & rehabilitation	4 themes identified:	14
						Health professionals	Individuals with multiple sclerosis currently driving: 5	Individuals with multiple sclerosis no longer licenced/ driving: Male = 33.3%	Individuals with multiple sclerosis no longer licenced/ driving: Mean age = 58.3 years (SD = 13.2; Range = 18-65)		1) From self-management to formal assessment –journey of uncertainty & emotional dilemmas	
							Individuals with multiple sclerosis no longer licenced /driving: 6	Health professionals: NR	Health professionals: Mean age = NR		2) Loss of driving means loss of independence & accompanied by grieving & adjustments	

(*continued on next page*)

Table 4 (*continued*)

Study	Study design	Comparison group	Intervention group	Study period	Study setting-country	Study population	*N* (participants)	Gender (%)	*M* age (range)	Outcome measures	Summary of key findings	COREQ score
							Health professionals: 6				3) Alternative transport is challenging & unsatisfactory 4) Gaps in Information & service provision	
(Bogner et al., 2004)	Focus groups	No	No	NR	U.S.	Family physicians	20	NR	NR	Barriers to assessing fitness to drive in older drivers in primary care	Physicians concerned re: being liable for results of driving-related screening /assessments	13
										Usefulness of neuropsychological tests for assessing driving ability	Physicians concerned re: patients reacting unfavourably to results of driving screening/ assessment Physicians need brief, effective, & feasible assessment	
(Byszewski et al., 2010)	Semi-structured interviews	No	No	2004	Canada	Patients with dementia who were told to cease driving & their caregivers	Total: 30	Patients: Male = 47%	Patients: Mean age = 81.0 years (SD = NR; Range = NR)	Perspectives of patients with dementia who were told to cease driving & their caregivers	Most patients agreed/ resigned themselves re: recommendations for driving cessation	17
							Patients: 15 Caregivers: 15	Caregivers: NR	Caregivers: NR		Of those who did not, reactions included shock, anger & denial Almost all caregivers agreed with recommendations to cease driving	
(Jones et al., 2012)	Semi-structured interviews & focus groups	No	No	2009	Australia	General Practitioners	Total: 16 Metropolitan GPS: 7 Rural GPs: 9	Male = 56.3%	NR	GPs' perspectives re: assessing fitness to drive in older & functionally impaired patients	Unsure whether they or DLA should have responsibility for assessing patients' fitness to drive Assessing fitness to drive challenging, can be anxiety-provoking for patients	16

et al., 2007). McLachlan and colleagues (McLachlan et al., 2007) administered a self-reported survey regarding driving and motor vehicle crash involvement with two groups of Canadian participants with epilepsy – one group living in Ontario which has mandatory medical reporting laws (n = 202) and one group living in Alberta which has discretionary reporting laws (n = 223). The authors also administered the survey to a group of control drivers who did not have epilepsy and who were living in the same areas for comparison (n = 375). The results of the survey revealed that the lifetime and one-year crash rates for licensed adults with epilepsy were not significantly different to licensed controls. In addition, the lifetime and one-year crash rates for licensed adults with epilepsy were not significantly different across licensing jurisdictions with and without mandatory medical reporting laws. As noted in Table 2, the quality of the evidence described in this study was rated as 'fair'. The authors noted that these findings were based on self-report, and therefore could be an underestimate of the crash rates for drivers with epilepsy if these participants were not truthful. However, the authors argued that other responses to their survey were consistent with expected findings and suggested that the anonymous format of the survey may have contributed to eliciting accurate information (Table 4).

More recently, Agimi and colleagues (Agimi et al., 2017) conducted a nationwide analysis on the role of mandatory medical reporting on older driver (aged 60 years and older) crash hospitalisation rates in 37 U.S. states across six years 2004–2009). The authors reported that the laws had no impact on older driver crash-related hospitalisation rates, even for the oldest age group (i.e., 85 + years). They did note, however, that in-person vision assessments at license renewal were significantly associated with lower crash hospitalisation rates. This finding is consistent with that reported previously by Levy and colleagues and McGwin and colleagues (Levy et al., 1995; McGwin et al., 2008). Agimi and colleagues did note that these findings are based on crash-related hospitalisations alone, and do not include crash-related fatalities. Furthermore, the authors noted that the potential effectiveness of mandatory medical reporting laws for reducing crash risk rely on medical and other health practitioners actually reporting their patients with medical and other fitness to drive relevant conditions to driver licensing authorities. As noted in Table 2, the quality of the evidence described in this study was rated as 'good'. However, as noted below in 3.4.3, there is some evidence to suggest that medical and other health practitioners, even in jurisdictions with mandatory medical reporting laws, do not report their patients to driver licensing authorities.

The review also identified one study that concluded that mandatory medical reporting does reduce crash risk. Redelmeier and colleagues (Redelmeier et al., 2012) identified patients through validated population-based databases in Ontario (Canada, n = 100,075) who had received a medical warning from a medical and/or other health practitioner (n = 6,098) who judged them to be potentially unfit to drive. The authors noted that the typical patient was a 60-year-old male who lived in an urban location and who had multiple outpatient clinic visits during the year before the warning. In addition, the authors noted that most patients (95%) had received at least 1 of the 20 most common diagnoses (e.g., alcoholism, epilepsy, and dementia), and 21 percent had received at least 5 of the diagnoses. They then analysed emergency department visits following a motor vehicle crash (where the patient was the driver) across a three-year baseline interval before the warning and a subsequent 1-year interval after the warning. They found that during the baseline interval, there were 1430 motor vehicle crashes in which the patient was driving and presented to the emergency department, compared to 273 motor vehicle crashes during the subsequent interval, representing a 45 percent reduction in the annual rate of motor vehicle crashes per 1,000 patients after the warning. In addition, Porter and colleagues (Porter et al., 2013) noted that these findings should interpreted with caution for three reasons: 1) the warnings described by Redelmeier and colleagues were made to patients and the physicians needed to report their patients to the licensing authority, and therefore it is unclear how many of the drivers had licenses that were suspended outright and therefore were not driving at all after the physician warning; 2) it is not possible to determine whether any of these motor vehicle crashes were deemed to be at-fault crashes, and 3) the absolute risk reduction was small (4.76 vs. 2.73 crashes per 1000 patients), and therefore the results are likely to be clinically insignificant as the number of patients who would need to be warned by their physician and reported to a licensing authority to prevent a single motor vehicle crash would be very large. As noted in Table 2, the quality of evidence described in this study was rated as 'good'. However, the authors also reported that mandatory medical reporting laws also resulted in unintended public health implications (e.g., exacerbated mood disorders, compromised physician-patient relationships, etc.). These public health implications are discussed in more detail in Section 3.3.5.

3.3.5. What are the public health and other implications of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions?

The review identified seven significant public health implications associated with mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions. These implications are described in more detail below.

3.3.5.1. Importance of a driver's licence for maintaining mobility. Driving was identified as an important part of maintaining an independent lifestyle, and that the loss of a license (due to a medical condition) often has a negative effect on an individual's quality of life. Archer and colleagues reported that having a valid license is a valued possession for many drivers, which is often easier to keep than to regain (Archer et al., 2014). Further Jones and colleagues (Jones et al., 2012) reported that GPs were very aware that their patients rely on their licence for social, recreational and wellbeing purposes (Jones et al., 2012). Consequently, mandatory medical reporting laws place medical and other health practitioners in a difficult position of balancing their patient's mobility and independence and their legal and ethical obligation to protect their patient's and the public's safety (Byszewski et al., 2010; Chan et al., 2013; Jones et al., 2012) (see Section 3.3.5.7 below).

3.3.5.2. Attitudes regarding addressing patients' medical fitness to drive. The review identified mixed attitudes from medical and other health practitioners regarding the frequency with which they address their patients' medical fitness to drive during their medical

consultations. Drazkowski and colleagues reported that only one-third (35%) of patients with new-onset epilepsy self-reported that they had been counselled by their medical or health practitioner on seizures in a U.S. jurisdiction with mandatory medical reporting laws (Drazkowski et al., 2010). This suggests that, even in licensing jurisdictions with mandatory medical reporting laws, medical or health practitioners may not assess or address fitness to drive concerns, and therefore patients may not be reported to the relevant licensing authority, and therefore may not be effective in increasing reporting. Likewise, Adler and Rottunda (Adler and Rottunda, 2011) noted that only 58.6 percent of physicians in the U.S. states of North and South Carolina (which do not have mandatory medical reporting laws) self-reported that they addressed fitness to drive issues with patients who had a diagnosis of dementia. However, Beran reported that when concerned regarding a patient who was driving contrary to medical advice, 30.4 percent of Australian physicians (across different licensing jurisdictions) self-reported that they discussed the issue with family/friends (without patient consent), 52.2 percent reported the patient to the licensing authority, 17.4 percent reported without patient's knowledge and 17.4 percent threatened to send a report (although they did not send it) (Beran, 1998). Another U.S. study found that, despite no requirements to counsel patients about driving (and no mandatory medical reporting laws), more than three quarters of physicians and specialists self-reported that they actually discussed fitness to drive issues with patients (77%), and that neurologists, neurosurgeons and ophthalmologists were significantly more likely than GPs and internists to self-report that they discuss driving issues (90.9% vs. 74.7%) (Drickamer and Marottoli, 1993). Similarly, Shanahan and colleagues (Shanahan et al., 2007) found that up to 84 percent of public hospital doctors in South Australia discussed fitness to drive with patients, suggesting that some physicians have a high level of involvement in assessment of driving abilities. Given that medical practitioners in South Australia are required to notify the licensing authority regarding patients with any medical conditions, diseases or disabilities that could influence their ability to drive to the point where they present a danger to themselves and/or the public by continuing to drive, these findings may provide some evidence that mandatory medical reporting laws may increase the likelihood that fitness to drive concerns are addressed with patients.

3.3.5.3. Attitudes regarding responsibility for assessing patients' medical fitness to drive and reporting to licensing authority. The review identified mixed attitudes regarding medical and other health practitioner's responsibility for assessing their patients' medical fitness to drive and reporting them to the licensing authority. For example, while many medical and other health practitioners in the U.S. and Canada believed that their patients' fitness to drive should be addressed, many did not routinely assess their patients' fitness to drive, and few felt qualified to do so (Brooks et al., 2011; Elgar and Smith, 2018; Jang et al., 2007). In addition, several studies reported that while many medical and other health practitioners felt that it was their responsibility to discuss fitness to drive issues with their patients, it was not their responsibility to report them to the licensing authority. For example, most physicians/specialists in the British Geriatrics Society believed that it was their responsibility to provide advice or counsel their patients about fitness to drive issues. However, fewer thought it was their responsibility to report unfit /unsafe drivers to the licensing authority, unless the patient was a danger to themselves or other drivers (Gillespie and McMurdo, 1999). This finding was replicated in Australia by Sims and colleagues (Sims et al., 2012) who reported that 85 percent of GPs in the state of Victoria discussed their patients' fitness to drive, but only 21 percent felt that they should have primary responsibility for declaring patients' fitness to drive (Sims et al., 2012). Similarly, more than three-quarters of Australian neurologists (79%) indicated that doctors should not have to report all patients with epilepsy to the licensing authority (Beran et al., 2007). Although the majority of neurologists (75.9%) supported reporting non-compliant patients to the licensing authority, only 29.6 percent reported that they actually do this (i.e., 'usually' or 'always'). Similarly, the majority of Saudi Arabian physicians (85%) reported that the responsibility of reporting patients to the licensing authority lies elsewhere (Alkharboush et al., 2017); 38 percent of physicians reported that this should be the responsibility of the licensing authority and 23 percent reported that patients should self-report to licensing authorities (23%) (Alkharboush et al., 2017). Indeed, GPs registered with the Irish College of General Practitioners were evenly divided regarding whether they should be primarily responsible for reporting patients who are unfit to drive (48%, 51%, respectively) (Kahvedžić et al., 2015). On the other hand, Cable and colleagues (Cable et al., 2000) reported that 75.5 percent of geriatricians from the U.S. agreed that they are responsible for reporting patients with dementia who drive and who are potentially dangerous. However, there was no difference between geriatricians from the U.S. state of California (which has mandatory medical reporting laws) and geriatricians from other U.S. states (without mandatory medical reporting laws) (Cable et al., 2000). In addition, as noted earlier, most geriatricians would contact the licensing authority if they were concerned, despite the objections of their patient (86.4%) or their patient's family (72.9%). Interestingly, in the case of reporting of alcohol-impaired drivers, Chang and colleagues (Chang et al., 1992) found that 78 percent of U.S. emergency physicians were in favour of mandatory medical reporting. However, they also expressed significant concerns regarding: violation of physician-patient confidentiality, belief that alcohol testing should be used for medical reasons only, fear of incriminating the patient, concern about inhibiting patients from seeking treatment, as well as a sense that the problem of alcohol-impaired driving was a legal, rather than a medical, problem.

Several studies reported support from medical and other health practitioners for discretionary or voluntary reporting across a range of jurisdictions in Switzerland, the U.S. and Australia (Eggert et al., 2012; Elgar and Smith, 2018; Gergerich, 2015). For example, Elgar and Smith (Elgar and Smith, 2018) surveyed sleep and electro-physicians in the state of South Australia (Australia), which has mandatory medical reporting laws, and only one-quarter (23.5%) agreed with mandatory medical reporting laws, while the remaining physicians would prefer reporting to be voluntary or discretionary or that physicians never have to report their patients (55.9 & 17.6%, respectively). Similarly, Gergerich (Gergerich, 2015) reported that less than half of geriatricians treating patients with dementia in the U.S. state of Arkansas supported mandatory medical reporting laws (45%).

3.3.5.4. Confidence, knowledge and skills relating to assessing medical fitness to drive. The review identified mixed findings regarding medical and other health practitioners' confidence in their ability to assess fitness to drive. For example, Kahvedzic and colleagues (Kahvedžić et al., 2015) found that up to 69 percent of GPs registered with the Irish College of General Practitioners reported feeling 'confident/very confident' in assessing fitness to drive. Likewise, Sims and colleagues (Sims et al., 2012) reported that more than half of Australian GPs (54%) were confident in their capacity to assess unfit drivers. However, Marshall and colleagues reported that one-third of physicians in Canada had low levels of confidence in their ability to assess their patients' fitness to drive (33%) (Marshall et al., 2012). Similarly, only 13.7 percent of Irish GPs reported confidence in assessing their patients' fitness to drive (Omer et al., 2014).

Limited knowledge of assessment guidelines among medical and other health practitioners may account for their lack of confidence in reporting potentially unfit/unsafe drivers (Shanahan et al., 2007). For example, several studies noted that physician's knowledge regarding fitness to drive guidelines within Canada and the potential impact of medical conditions on crash risk was generally poor (Alkharboush et al., 2017; Marshall and Gilbert, 1999). Likewise, Gergerich (Gergerich, 2015) found that less than half of the geriatricians in the U.S. state of Arkansas, who were treating patients with dementia (48%), knew whether it was mandatory to report patients/drivers with dementia to the licensing authority. Similarly, Cable and colleagues (Cable et al., 2000) reported that more than one-quarter of geriatricians in the U.S. (28.5%) reported their lack of knowledge of procedures for reporting patients with dementia who were potentially dangerous. Likewise, medical and other health practitioners in the U.K. providing care for patients following a minor stroke or TIA showed limited knowledge of fitness to drive regulations for both private and commercial licenses (Batool et al., 2014). This limited knowledge may also contribute to medical and other health practitioners' lack of support for mandatory medical reporting of unfit drivers. For instance, Beran and colleagues (Beran et al., 2007) found that although 77.0 percent of Australian physicians endorsed physician-based fitness to drive assessments for patients with epilepsy, more than half of the neurologists (54.9%) did not think that GPs would be sufficiently knowledgeable.

Interestingly, Cable and colleagues reported that U.S. geriatricians in jurisdictions without mandatory medical reporting laws were significantly more likely to be unsure of how to report their patients (31.8%) compared to geriatricians in jurisdictions with mandatory medical reporting (9.8%) (Cable et al., 2000). Similarly, Chan and colleagues (Chan et al., 2013) reported that all (100%) physicians in the province of Ontario (Canada) were aware of their legal obligation to report patients who are medically unfit/unsafe to drive. These findings may point to the potential positive benefits of mandatory medical reporting laws in terms of improving knowledge regarding how to report patients to the licensing authority. In addition, several studies suggested that knowledge regarding fitness to drive may differ across specialties (Batool et al., 2014). For example, physicians in the U.K. were significantly more likely to correctly state that patients were responsible for reporting their medical condition to the licensing authority (82.1%) compared with other health professionals (60.0%) (Batool et al., 2014). Another study within the U.S. reported that, although few physicians reported their patients to the licensing authority (14%), this differed by speciality; neurologists were more likely (33.3%) and ophthalmologists were less likely (4.6%) than other physicians to report patients to the licensing authority (13.4%, 14.9%, respectively) (Drickamer and Marottoli, 1993).

3.3.5.5. Need for effective assessment tools, definitive guidelines and further education for assessing fitness to drive. Several studies noted that one of the barriers to assessing patients' fitness to drive is the lack of tools and resources available to medical and other health practitioners (Chan et al., 2013). Medical and other health practitioners in the U.S., Canada and Ireland concluded that if they were to be responsible for determining fitness to drive, they need a brief, effective and feasible assessment and / or strategy for evaluating patients within a primary healthcare or other clinical setting, as well as need more comprehensive and definitive guidelines (Bogner et al., 2004; Chan et al., 2013; Omer et al., 2014).

In addition to effective assessment tools and definitive guidelines, several studies noted that medical and other health practitioners in the U.S., Canada, Switzerland and Australia reported that they would benefit from further education if they were to be responsible for determining patients' fitness to drive – particularly with respect to their legal and ethical responsibilities when addressing unfit/unsafe driving (Adler and Rottunda, 2010, 2011; Gergerich, 2015; Jang et al., 2007; Marshall et al., 2012; Omer et al., 2014; Pfäffli et al., 2012; Sims et al., 2012). In addition, based on their findings regarding the effect of mandatory medical reporting on patient self-reported behaviour from randomly selected drivers in South Australia (Australia), Elgar and colleagues suggested that education may be a more effective way to encourage potentially unfit/unsafe drivers to self-report to the licensing authority, rather than mandating medical and other health practitioners to report their patients to the licensing authority (Elgar et al., 2016). Self-regulation, that is adjusting driving behaviours to accommodate medical conditions and/or functional impairments associated with the medical condition(s), may be a potentially effective strategy for drivers with medical conditions and/or functional impairments to maintain safe driving, as well as maintaining mobility and independence (Archer et al., 2014), so long as they retain intact insight and decision making capacity.

3.3.5.6. Negative impact of mandatory medical reporting on physician-patient relationship. Many studies described how mandatory medical reporting across a range of licensing jurisdictions (i.e., Canada, the U.S. and Australia) adversely affected the physician-patient relationship (Archer et al., 2014; Bogner et al., 2004; Chan et al., 2013; Elgar et al., 2016; Elgar and Smith, 2018; Jones et al., 2012; Redelmeier et al., 2012; Salinsky et al., 1992; Shanahan et al., 2007; Sims et al., 2012). For example, there were frequent reports of negative patient behaviour towards the medical and other health practitioner, including verbal and physical abuse, when provided the results of a screening test and / or assessment, or when they were informed that they would be reported to the licensing authority (Bogner et al., 2004; Elgar and Smith, 2018). In addition, several studies described other negative patient behaviours, such as withholding information or lying to their medical and other health practitioner about symptoms and diagnoses, 'doctor shopping', or avoiding seeking treatment due to their fear of being reported to the licensing authority, thus further jeopardising their health

(Archer et al., 2014; Elgar et al., 2016; Elgar and Smith, 2018; Jones et al., 2012; McLachlan et al., 2007; Redelmeier et al., 2012; Salinsky et al., 1992). In addition, potential or actual reporting to the licensing authority by medical and other health practitioners have been associated with an increase in subsequent emergency department visits for depression and a decrease in return visits to the responsible medical and/or other health practitioner, disrupting regular physician-patient contact (Redelmeier et al., 2012).

3.3.5.7. Conflict of interest and legal liability. Several studies noted that the requirements of mandatory medical reporting in Canada and Australia placed medical and other health practitioners in the difficult position of balancing: patient autonomy, supporting the negative health and psychosocial consequences following driving cessation, and their legal and ethical obligation to protect patient and public safety (Byszewski et al., 2010; Chan et al., 2013; Jones et al., 2012). Most medical and other health practitioners in studies conducted within the U.S. and Ireland also reported fears of potential conflicts of interest when mandated to report their patients to the licensing authority (Brooks et al., 2011; Gergerich, 2015; Omer et al., 2014). In addition, several studies further suggested that medical and other health practitioners were concerned about their legal liability for the results of a driver screening and/or assessment (Bogner et al., 2004; Kahvedžić et al., 2015). For instance, Sims and colleagues (Sims et al., 2012) reported that approximately three-quarters (74%) of GPs in Victoria (Australia) expressed concern about legal liability when asked to describe their experiences in assessing their patients' fitness to drive.

4. Discussion

4.1. Summary of evidence

This study systematically reviewed the available literature to synthesise evidence on key issues relating to the efficacy of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions by medical and other health practitioners. The review examined 50 studies (45 quantitative studies [cross-sectional studies: n = 43; case-control studies: n = 2] and 5 qualitative studies) published between 1992 and 2018. The quantitative studies were mostly retrospective self-report/face-to-face surveys with medical and other health practitioners or drivers with medical and other fitness to drive relevant conditions (n = 35). The qualitative studies were all semi-structured interviews or focus groups with medical and other health practitioners, drivers with medical and other fitness to drive relevant conditions, or individuals from licensing authorities. Participant populations of included studies involved a diverse range of medical and/or other health practitioners (n = 31: e.g., cardiologists, emergency physicians, endocrinologists, family physicians, GPs, general surgeons, geriatric medicine, internal medicine, neurologists, neurosurgeons, psychiatrists, radiation oncologists, rehabilitation specialists and sleep/electro physicians etc.), drivers/patients (n = 18), or a combination of drivers and law enforcement officers/licensing authorities (n = 1). Most studies were conducted in the U.S. (n = 19), Canada (n = 11), or Australia (n = 10).

The findings of the review suggest that there is inconclusive evidence regarding the effectiveness of mandatory medical reporting by medical and other health practitioners for increasing reporting of drivers with medical and other fitness to drive relevant conditions to the licensing authority. Of the seven studies that specifically examined this issue (Cable et al., 2000; Elgar and Smith, 2018; Jang et al., 2007; Louie et al., 2012; Marshall et al., 2012; McLachlan and Jones, 1997; Redelmeier et al., 2008), four studies (Jang et al., 2007; Louie et al., 2012; Marshall et al., 2012; McLachlan and Jones, 1997) reported that medical and other health practitioners in jurisdictions with mandatory medical reporting laws were significantly more likely to report potentially unfit/unsafe drivers to the licensing authority than those in jurisdictions without mandatory medical reporting laws (i.e., discretionary or voluntary reporting laws). It should be noted that the quality of evidence ratings for these four studies was 'good'. The three remaining studies (quality of evidence ratings: 'good' = 1; 'fair' = 2) found that mandatory medical reporting laws did not increase the reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities (Cable et al., 2000; Elgar and Smith, 2018; Redelmeier et al., 2008). Potential explanations for these mixed results are that the identified studies were conducted in different licensing jurisdictions with different mandatory medical reporting laws and other relicensing requirements, and included a diverse range of medical and other health practitioner populations who are likely to differ in terms of the patients they see and how often they need to report them to the licensing authority.

In addition, the review identified mixed attitudes from medical and other health practitioners in terms of their responsibility for assessing their patients' fitness to drive and reporting them to licensing authorities. Several studies reported that while many medical and other health practitioners felt that it was their responsibility to discuss medical fitness to drive issues with their patients (Brooks et al., 2011; Elgar and Smith, 2018; Jang et al., 2007), they did not believe that it should be their responsibility to report them to the licensing authority (Alkharboush et al., 2017; Beran et al., 2007; Gillespie and McMurdo, 1999; Kahvedžić et al., 2015; Sims et al., 2012).

There were also mixed findings regarding medical and other health practitioners' confidence in their ability to assess fitness to drive, which may be due to their limited knowledge regarding how to assess fitness to drive or how to report patients that are potentially unfit or unsafe. Interestingly, several studies demonstrated that medical and other health practitioners in jurisdictions without mandatory medical reporting laws were significantly more likely to be unsure of how to report their patients compared to medical and other health practitioners in jurisdictions with mandatory medical reporting laws (Cable et al., 2000; Chan et al., 2013). These findings may point to the potential positive benefits of mandatory medical reporting laws in terms of improving medical and other health practitioners' knowledge regarding how to report patients to licensing authorities. However, other fitness to drive reporting system issues need to be addressed for this awareness and knowledge to translate to actual referrals. Several studies also noted that medical and other health practitioners need: 1) effective screening/assessment tools for evaluating drivers' fitness to drive

in a primary healthcare or other clinical setting (Chan et al., 2013), 2) definitive fitness to drive guidelines (Bogner et al., 2004; Chan et al., 2013; Omer et al., 2014), and 3) further education for assessing fitness to drive - particularly with respect to their legal and ethical responsibilities when addressing unfit / unsafe driving (Adler and Rottunda, 2010, 2011; Gergerich, 2015; Jang et al., 2007; Marshall et al., 2012; Omer et al., 2014; Pfäffli et al., 2012; Sims et al., 2012). In addition, the review identified that there is no clear evidence to suggest that mandatory medical reporting by medical and other health practitioners is effective in reducing crash risk for drivers with medical and other fitness to drive relevant conditions. Only three studies (quality of evidence ratings: 'good' = 1; 'fair' = 2) specifically investigated the relationship between mandatory medical reporting and crash rates – with two suggesting there is no reduction in crash rates (Agimi et al., 2017; McLachlan et al., 2007) and one suggesting that there is a reduction in crash rates (Redelmeier et al., 2012). However, as described above Section 3.3.4, Porter and colleagues (Porter et al., 2013) noted that this finding should interpreted with caution for three reasons: 1) it is unclear how many of the drivers had licenses that were suspended outright and therefore were not driving following a physician warning; 2) it is not possible to determine whether any of these motor vehicle crashes were deemed to be at-fault, and 3) the results are likely to be clinically insignificant as the number of patients who would need to be warned by their physician and reported to a licensing authority to prevent a single motor vehicle crash would be very large. Interestingly, Redelmeier and colleagues also cautioned that while mandatory medical reporting laws may reduce crash rates, they may also have unintended public health implications.

Indeed, the review identified several significant public health implications of mandatory medical reporting of drivers with medical and other fitness to drive relevant conditions. For example, several studies noted that the requirements of mandatory medical reporting laws place medical and other health practitioners in the difficult position of balancing: patient autonomy, supporting the negative health and psychosocial consequences following driving cessation, and their legal and ethical obligation to protect their patient's and the public's safety (Byszewski et al., 2010; Chan et al., 2013; Jones et al., 2012). Many studies also described how mandatory medical reporting adversely affects the physician-patient relationship (Archer et al., 2014; Bogner et al., 2004; Chan et al., 2013; Elgar et al., 2016; Elgar and Smith, 2018; Jones et al., 2012; Redelmeier et al., 2012; Salinsky et al., 1992; Shanahan et al., 2007; Sims et al., 2012). For example, medical and other health practitioners reported that when they provided the results of screening test and/or assessment to a patient, or informed a patient that they would be reported to the licensing authority, the patient verbally and / or physically abused them (Bogner et al., 2004; Elgar and Smith, 2018). In addition, medical and other health practitioners reported that patients may also withhold information or lie to them about symptoms and diagnoses, 'doctor shop' or avoid seeking treatment due to their fear of being reported to the licensing authority, thus further jeopardising their health (Archer et al., 2014; Elgar et al., 2016; Elgar and Smith, 2018; Jones et al., 2012; McLachlan et al., 2007; Redelmeier et al., 2012; Salinsky et al., 1992).

4.2. Strengths and limitations

Several limitations should be noted. First, the results from most of the identified studies (n = 40) were based on self-report (i.e., retrospective self-report surveys, focus groups, semi-structured interviews) – where response rates varied but were generally low – and therefore may be subject to response bias (Marshall et al., 2012; Ménard et al., 2006; Omer et al., 2014; Sims et al., 2012). The response rates may depend on whether medical and other health practitioners are satisfied with the status quo of mandatory medical reporting laws. For example, medical and other health practitioners who want to change in laws regarding mandatory medical reporting may be more likely to participate in a survey as opposed to medical and other health practitioners who are satisfied with mandatory medical reporting laws (Elgar and Smith, 2018; Marshall et al., 2012; Shanahan et al., 2007). Secondly, the identified studies were conducted in numerous licensing jurisdictions, with different mandatory medical reporting laws and other relicensing requirements (e.g., mandatory submission of a medical report or requirement for an on-road test which applies at a certain age, etc.), which may limit the generalisability of the findings. For example, many studies focused on a single licensing jurisdiction and set of mandatory medical reporting laws, often without reference to a comparison group, which makes it difficult to ascertain whether the low levels of confidence, knowledge and reporting of unfit / unsafe drivers is due to medical and other health practitioner's awareness, knowledge, or behaviour, or whether it is due to the specific characteristics of the set of mandatory medical reporting laws they are working with (Brooks et al., 2011). Thirdly, the results from the identified studies are based on a diverse range of participant populations. In particular, responses from medical and other health practitioners, included cardiologists, emergency physicians, endocrinologists, family physicians, GPs, general surgeons, geriatric medicine, internal medicine, neurologists, neurosurgeons, psychiatrists, radiation oncologists, rehabilitation specialists and sleep/electro physicians etc. There is likely to be significant differences between GPs/primary care physicians and other medical specialists (e.g., geriatricians, neurologists, etc.) in terms of the patients they see, and how often they need to address medical fitness to drive issues and/or report their patients to the licensing authority – which may explain some of the inconsistencies identified within the review. Fourthly, the quality of evidence across both quantitative and qualitative studies was most likely to be 'fair' or moderate (quantitative studies: 80%; qualitative studies: 100%), suggesting potential risk of bias, which makes it difficult to confidently draw conclusions based on the study findings. Finally, while the review identified one study that captured the perspectives of carers of individuals who had ceased driving (Byszewski et al., 2010), it did not identify any other studies that captured the perspectives of carers/family members who may be struggling to manage medically impaired drivers who continue to drive with poor functional skills/insight against medical advice. For this latter group, mandatory medical reporting may support appropriate referral to licensing authorities, but only if the driver attends a medical or other health practitioner appointment, where medical fitness to drive issues can be discussed and accurately evaluated.

4.3. Implications

Based on the results of identified studies, there is some evidence to suggest that mandatory medical reporting laws are associated with an improvement in medical and other health practitioners' knowledge regarding how to report patients to licensing authorities, however there is inconclusive evidence regarding whether these laws: 1) increase the reporting of drivers with medical and other fitness to drive relevant conditions to licensing authorities, or 2) reduce the crash risk of these drivers. There was emerging evidence that mandatory medical reporting adversely affects the physician-patient relationship, including verbal and physical abuse directed towards medical and other health practitioners. In addition, medical and other health practitioners reported that patients may also avoid medical treatment, due to their fear of being reported to licensing authorities, which may further jeopardise their health. In addition, several studies identified a pressing need for support tools to assist medical and other health practitioners with assessing and managing their patients' fitness to drive (Parliamentary Advisory Council for Transport Safety, 2016). It should be noted that the identified studies were conducted in numerous licensing jurisdictions, with different mandatory medical reporting laws and other relicensing requirements, and across a diverse range of participant populations, which may limit the generalisability of the findings. It is also important to note that the medical fitness to drive system is impacted by many factors as discussed above (e.g., availability of fitness to drive guidelines and tools, post graduate education, etc.) and that mandatory medical reporting requirements may or may not be one of many interventions that support system effectiveness. Based on the findings of this systematic review, there are a number of implications for advancing knowledge and practice in this area:

1. A population-based controlled research study in multiple jurisdictions is warranted to specifically investigate the efficacy of mandatory medical reporting by medical and other health practitioners as a means to reduce road trauma and enhancements that could be piloted;
2. The nature of mandatory medical reporting requirements needs to be audited at a jurisdictional level and cross-referenced with practices by medical and other health practitioners and crash-rates to improve the evidence-base on the relationship between medical fitness to drive and crash risk, and
3. Given the emerging evidence relating to a potential conflict of interest for physicians' mandatory medical reporting, other options should be explored to identify which professionals might be best placed to assess and report medical fitness to drive.

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Conflict of interest

None.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at https://doi.org/10.1016/j.jth.2019.02.005

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