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# A systematic review of road traffic suicides: Do we know enough to propose effective preventive measures?

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ABSTRACT

Suicide on the road network is a recognized suicide method. We conducted a systematic review with the main aim of summarizing the existing research literature on road traffic suicides covering all road users who attempt or die by suicide in road traffic. A secondary and more specific aim was to examine the consequences for possible secondary participants. Our ultimate aim was to identify prevention measures. Relevant publications (N = 48) were identified in *Medline*, *PsycInfo*, *Scopus*, and *Web of Science* databases and supplemented with three studies from a personal database. We covered and discussed the following twelve topics: Countries where the data has been collected; Publication years – a historical overview; The main purpose of the studies; Data sources; How suicide was confirmed/defined (Differences between decisions by crash investigators and those of official forensic examinations); The proportion of suicides on roads; Types of crashes; The second party; Who dies by suicide in road traffic? (Age and gender, Mental health history, and Other background factors); Why people choose this method of suicide; The prevention of road suicides; An overview of issues regarding quality of studies. We conclude that road traffic suicides are not a well-researched phenomenon, especially concerning the reasons why people choose this specific method, the consequences for the possible second party, and specific preventive measures.

## 1. Introduction

Little is known about why people choose a specific method of suicide. Violent suicides are more prevalent among men than women (Knipe et al., 2022), and the availability of means (e.g., guns, high places, railways) is an important factor (Cox et al., 2013). A high determination to end one's life might lead to the selection of a more lethal method, while other motives, such as communication of distress, might make a person choose a less lethal method (Brown et al., 2004; Denning et al., 2000; Liotta, Mento, & Settineri, 2015). Crashing a motor vehicle or jumping in front of a motor vehicle driven by someone else represents a violent form of suicide that will very likely result in a fatality or serious injuries. Who are the people who choose to die by suicide in road traffic? What background and situational factors are related to this suicide method?

The purpose of suicide is typically not to physically harm others. However, individuals who choose to crash a vehicle into another,

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typically heavy, vehicle might endanger the lives of its occupants. Even if the occupants of the other vehicle survive, psychological consequences might be long lasting (Radun et al., 2020). Little is known how often these individuals are injured, and how they cope after the event. Do those who choose this suicide method do it in an impulsive manner, e.g., latent suicidal ideation manifests itself at some point during extensive driving exposure, or do they plan it after considering several methods? Do these people in serious distress consider the possible harm they might cause to other people who they have very likely never met before, or do they just underestimate the potential danger to others?

With these questions in mind, we conducted a systematic review on road suicides. Three previous (systematic) literature reviews exist on this topic. One is a 20-year-old report published in the Monash University's series (Routley et al., 2003). The other, a ten-year-old journal article, focused mostly on single-vehicle crashes (Pompili et al., 2012), although suicide crashes with another vehicle are common (Gauthier et al., 2015; Hernetkoski et al., 2009; Radun et al., 2019a). The third, also a journal article, has recently been published (Imants et al., 2022). However, we believe it omitted some relevant studies. Identified risk factors in these reviews included male gender, recent stressful life events, history of mental health problems, previous suicide attempts and suicidal ideation. However, an overall conclusion of these reviews is that road suicide is an underrecognized and underreported phenomenon, which consequently limits the development of specific preventive measures.

The primary objective of our systematic review was to summarize the existing literature on road suicides, overcoming the identified shortcomings of previous reviews. The population of interest consisted of all road users who attempted suicide or died by suicide in road traffic. The secondary objective, which goes beyond other reviews, was to examine the consequences of suicidal acts on roads for others who may have been directly affected by these acts. The ultimate aim was to identify prevention measures.

## 2. Methods

The protocol for this systematic review was registered in Prospero (RecordID = 208721) in 2020 and updated in 2022.

### 2.1. Search strategy

The following databases were searched for relevant publications: *Medline*, *PsycInfo*, *Scopus*, and *Web of Science*. The search strategy (see Supplementary file 1) was designed jointly by one of the researchers (IR) and a University of Helsinki information specialist. In short, the search strategy combined strings of terms related to the following areas: (1) suicides and (2) road crashes. The search was performed in August 2022 and resulted in 5,585 records, which were then imported into Zotero reference management software.

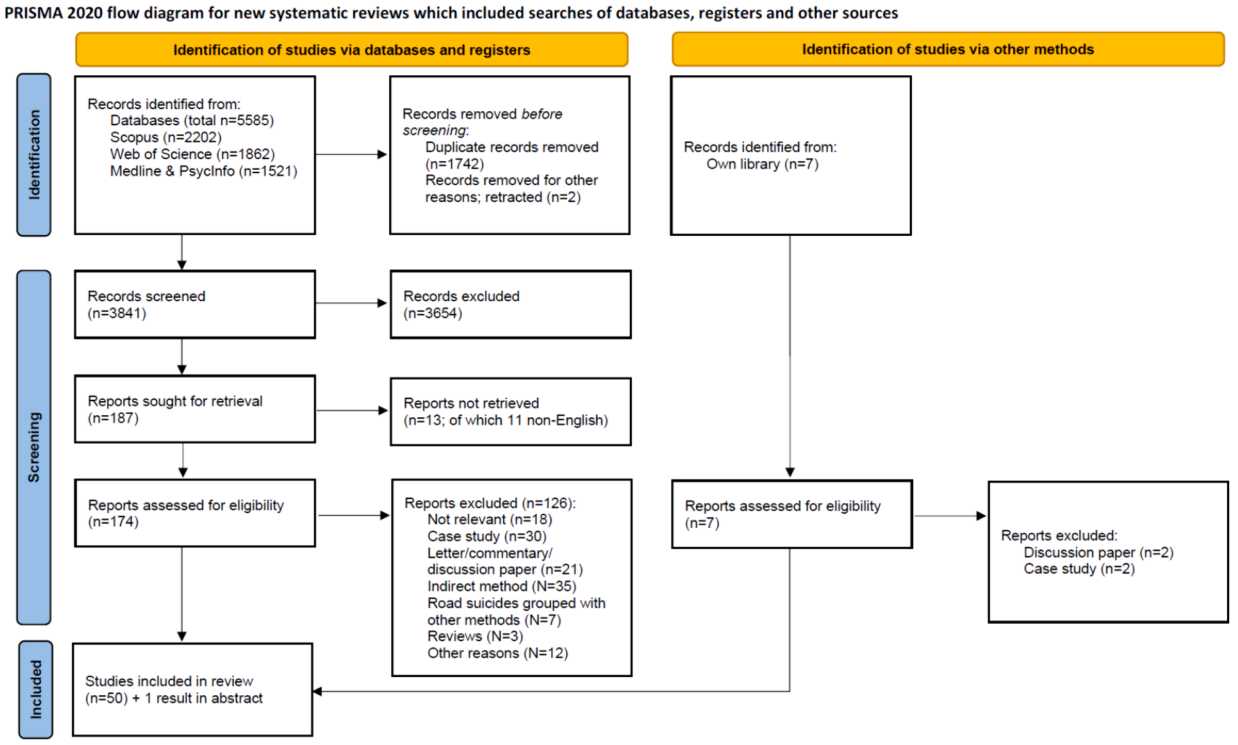


**Fig. 1.** PRISMA 2020 flow diagram of included studies.

One researcher (IR) manually removed duplicates and two retracted papers automatically identified by Zotero. Two researchers (IR & PK) independently screened the remaining titles and abstracts of 3,841 publications. Conflicts in inclusions were resolved in discussion between these two researchers without the need for the involvement of other members of the review team. This process resulted in 187 potentially relevant articles. The same researchers then independently screened full texts of the retrieved 174 articles and, after a discussion, identified 48 for data extraction. Three additional relevant papers from the authors' libraries were added in this phase. The reference lists of the identified articles were examined. The two researchers independently then extracted relevant data from the 51 articles (see Supplementary file 2), discussed each study, and agreed about the information presented in Table S1 (Supplementary file 3). The PRISMA 2020 flow diagram is shown in Fig. 1. Where possible we visited publishers' websites to check whether any of the final selected papers had been retracted; none of them were (31 August 2023).

### 2.2. Inclusion/exclusion criteria

Studies written in languages other than English were not automatically excluded if the abstract was available in English. If an abstract contained relevant results, we reported on such studies (N = 1); however, the limitations of this approach are acknowledged and noted in Table S1. We excluded studies that indirectly addressed the topic of road suicides, including studies that (i) analyzed the possible increase in road crashes following "publicized suicide stories" (e.g., Phillips, 1977), (ii) examined seasonal variation of suicides in general and in (single) motor vehicle crashes (e.g., Bollen, 1983), (iii) examined whether previous suicidal thoughts/attempts were related to later involvement in motor vehicle crashes (e.g., Bhatti, Thiruchelvan, & Redelmeier, 2019; Martiniuk et al., 2009), (iv) compared crash-involved drivers with various controls on various personality/mental health variables (e.g., Lam et al., 2005). Case studies and studies that focused on suicides involving trains were also excluded. Finally, we did not specifically search for nor included suicides by jumping from or onto the road network because this would significantly expand the review. Additionally, as noted by Hawton et al. (2021, p.49), "It is uncertain how individuals who self-harm by jumping on the road network differ from those who jump in other locations.".

### 2.3. Data extraction and synthesis

Given the large number of studies included in this review, the summary table is available in a supplementary Pdf file (Table S1) instead of including it in the main text. In the results and discussion sections, we summarize the findings of these studies under relevant topics, such as data sources, how the suicide was confirmed, who dies by suicide in road traffic, etc. For clarity, in that section as well as in the general discussion, the 51 studies included in our systematic were marked with an order number in which they appear in supplementary files two and three. In the general discussion, we offer our views about possible preventive measures.

We initially planned to use a quality assessment tool. However, given the large variability in the nature of studies this proved to be too difficult a task. Therefore, we have only provided comments and notes regarding each study. These often include our views about the strengths and limitations of the studies. They are summarized in 3.12, An overview of the quality issues.

## 3. Results and discussion

### 3.1. Countries where data have been collected

The countries in which data were collected for the studies included in our review can be roughly grouped into three distinctive categories: Nordic countries (N = 22; Finland (16), Sweden (4), and Norway (2)), English-speaking countries (N = 27; US (13), Australia (6), UK (5), Canada (1), Ireland (1), and New Zealand (1)), and German-speaking countries (N = 2; Germany (1) and Switzerland (1)).

Finland has the largest number of studies included in the review. As discussed recently (Radun et al., 2023), every fatal road crash in Finland is investigated by a multidisciplinary team for traffic safety purposes, which might result in better recognition of suicides (see Radun et al., 2019a[37] for more information about this Finnish investigation method). A database based on these investigations has often been used by traffic safety researchers. All but one (Huusko & Hirvonen, 1988[20]) of the Finnish studies included in our review had utilized this database.

We also identified several potentially relevant studies published in German (e.g., Handel, 1982; Greiner, 1988), French (Lacroix, Lacroix, & Doré, 1993), and Romanian (Kanaki et al., 2006). However, these are not included in our review as we were either unable to locate the reports (N = 11; Fig. 1), or they did not include an abstract in English or relevant results in an English abstract (among other reasons for exclusion, Fig. 1). A short communication paper with a very relevant title ("Does driver suicide occur in Iran?") was also not included as it does not include any data, only a short reference ("We could find no account of driver suicide from Iran.") (Pridmore et al., 2017).

In conclusion, it is somewhat surprising that we found original studies published in English based on data collected from only eleven countries, none of which are lower- or middle-income countries. The observed differences in the number of road suicide publications between countries are possibly related to the real number of suicides in road traffic; however, it has been shown that such positive correlation does not necessarily exist regarding all types of suicide research especially in the low- and middle income countries/regions, which might have high suicide rates, but few publications on suicides (Cai, Chang, & Yip, 2020). On the other hand, given the difficulties in recognizing road suicides (see section 3.5.), these differences could also be related to the attention and resources dedicated to the road crash investigation.

### 3.2. Publication years: A historical overview

The earliest publications on road suicides included in our review are from the 1960s (Hamburger, 1969 [15]; Macdonald, 1964 [27]; Selzer & Payne, 1962 [46]). During the same decade several other important papers were published. For example, Frank (1965) wrote a paper titled "Suicide in Automobile Accidents", while two years later, Litman and Tabachnick (1967) published an influential paper ("Fatal one-car accidents") in which they discussed road suicides from a psychoanalytic point of view. Although these two papers did not provide any original data to be extracted for the purpose of our review, they indicate that the topic of road suicides has long been recognized and discussed in scientific literature.

There was a sharp increase in the number of publications in the 1990s (Table 1). However, that does not necessarily reflect an increased interest in road suicides as the numbers are still quite low (one paper per year), especially considering the growth of scientific literature on suicidal behavior in general (Cai, Chang, & Yip, 2020). Nevertheless, eight articles have already been published in less than 3 years in the 2020s, suggesting growing interest in this topic.

### 3.3. The main purpose of the studies

Not all of the 51 studies included in the review focused solely on road suicides. In fact, nine studies (17.6%) only briefly mentioned road suicides, although we were able to extract relevant information. For example, Viklund et al. (2013)[48] investigated fatal crashes that resulted in a burning car and briefly reported that confirmed suicides represented 3.8% of the crashes while an additional 3.8% were suspected suicides. In 12 (23.5%) studies road suicides were partially in focus, while in thirty (58.8%) studies the primary focus was on road suicides. This, perhaps, further indicates that there is a limited number of studies specifically investigating road suicides.

### 3.4. Data sources

A variety of data sources was used in the studies. Some studies used fatal road crash databases and then either focused on suicide cases that had been defined as such by investigation teams (e.g., Radun et al., 2019a[37]), or the authors re-analyzed available data and attempted to identify suicide cases using their own criteria (e.g., Hernetkoski & Keskinen, 1998 [17]; Keskinen & Pasanen, 1990 [22]).

Other studies used national suicide databases and specifically analyzed those deaths that happened in road traffic (e.g., Gauthier et al., 2015 [14]; Milner & De Leo, 2012 [29]). Hawton et al. (2021)[16] analyzed non-fatal incidents registered in a monitoring system for self-harm presentations to a general hospital in England, and Isherwood et al. (1982)[21] analyzed cases of suicide attempers treated in a single hospital in New Zealand. Several studies analyzed cases recorded at trauma centers in the US (e.g., Barczyk et al., 2020 [4]; Bittner et al., 2010 [5]; Kliger & Sporty, 1993 [23]).

Some studies analyzed coroners' decisions (e.g., Connolly et al., 1995 [8]; Cooper & Milroy, 1994 [9]). For example, Connolly et al. (1995)[8] examined single road fatalities documented by four coroners with the aim of establishing whether some accidental deaths may have been disguised as suicides. Others examined deaths documented in forensic departments (e.g., Copeland, 1985 [10]; Morild, 1994 [30]) or based their report on cases from the author's own psychiatric practice (Macdonald, 1964 [27]).

In some studies, authors used multiple sources of information in their analysis (e.g., Björnstig et al., 2008 [6]; Kujansuu et al., 2017 [25]; Räisanen et al., 2019 [40]; Schmidt et al., 1972 [45]). For example, in a Swedish analysis of fatal passenger car collisions with other vehicles, the authors used five different datasets: "(1) the official police reported road accident statistics, (2) police investigations, (3) the Swedish Road Administration's (SRA) fatality crash investigations, (4) autopsy reports from the National Board of Forensic Medicine, and (5) death certificates" (Björnstig et al., 2008 [6]).

The large majority of studies were retrospective in nature. A rare exception is an Australian study, in which the authors prospectively analyzed the relationship between self-harm engagement (including those which were road-related) and crash risk among newly licensed drivers (Martiniuk et al., 2009[28]). However, they "were unable to discern whether a crash was due to the intention to injure or kill oneself" (Martiniuk et al., 2009[28]; p. 811).

### 3.5. How suicide was confirmed/defined

The certainty of a decision regarding suicide is often reported in the reviewed articles as: confirmed, probable, possible, or not a suicide. For example, a Swedish classification system uses a five-grade scale: certain suicide, strongly support suicide as a cause of

**Table 1**
The number of publications included in our review by the decade of publication.

| Decade | N | Percentage |
|---|---|---|
| 1960–1969 | 3 | 5.9 |
| 1970–1979 | 5 | 9.8 |
| 1980–1989 | 3 | 5.9 |
| 1990–1999 | 10 | 19.6 |
| 2000–2009 | 11 | 21.6 |
| 2010–2019 | 11 | 21.6 |
| 2020–2022 | 8 | 15.7 |
| **Total** | **51** | **100.0** |

death, not possible to determine whether it was a suicide or accidental death, almost certainly an accident, or a certain accident (Andersson & Sokolowski, 2022 [2]).

Recognizing self-destructive motives in crash causation is not easy. If the intention to die is not clearly communicated (e.g., a suicide note), crash investigators will have to rely on other cues, such as the crash circumstances (e.g., sudden change of direction, no braking, no seatbelt), reports from eyewitnesses and others who might be involved in a crash, and background information provided by family and friends together with information gathered from medical records. Combining several sources of information is typical for multidisciplinary investigation teams such as the Finnish fatal crash investigation method (e.g., Hernetkoski & Keskinen, 1998 [17]; Radun et al., 2019a[37]) and Swedish classification system of road crashes (Andersson & Sokolowski, 2022 [2]).

The definition of suicide typically depends on the data source. Authors of scientific studies rarely re-evaluate decisions made by someone else; they either accept them (e.g., Gauthier et al., 2015 [14]; Radun et al., 2019a[37]), or set their own criteria and make their own decisions (e.g., Hernetkoski & Keskinen, 1998 [17]; Keskinen & Pasanen, 1990 [22]). One exception is a Finnish study in which two forensic researchers re-evaluated decisions made by multidisciplinary investigation teams who investigate every fatal crash in Finland (Ohberg, Penttilä, & Lonnqvist, 1997 [32]). Their revaluation agreed in 85% of cases with the original decisions.

#### *3.5.1. Differences between decisions by crash investigators and those of official forensic examinations*

Official coroner investigations must rely on more solid evidence supporting suicide (e.g., a suicide note) compared to the criteria used, for example, by multidisciplinary teams investigating road crashes for traffic safety purposes. The reason for this lies in legal and insurance consequences following a suicide verdict (Huusko & Hirvonen, 1988 [20]; Selzer & Payne, 1962 [46]; Truebner et al., 1996 [47]). Edland (1971 [12], p.538) has summarized this practice in official forensic investigations as follows: "If we feel that suicide is a reasonable certainty, the certificate is signed as such, 'Vehicular Suicide.' If we feel that suicide is highly probable, it is signed 'Vehicular Suicide' with family consent, or as 'Undetermined' without." However, we are unaware whether and to what degree family consent possibly influences this practice.

Obtaining the family consent might not always be easy because some people attempt to disguise their suicide. They may do this because they do not want to bring "shame" to their family, as dying in a car crash may be regarded as more socially "acceptable" than dying by suicide (Morild, 1994 [30]). For example, Macdonald (1964 [27], p.3) reports a case of a woman who deliberately drove at a concrete overpass pillar while wearing a seatbelt because "She was confident she would not survive despite use of her safety belt, which was worn to dispel any suspicion of suicide.".

A thorough psychosocial investigation is likely to result in better detection of suicides among road crashes, especially because crash circumstances can sometimes mislead investigators as in the Macdonald (1964)[27] example above. Such thorough psychosocial investigations are necessary if the aim is to separate suicides from road crash statistics such as Sweden has done since 2010 (Andersson and Sokolowski, 2022 [2]).

**Table 2**
The prevalence of road suicides based on official databases.

| Type of data | Country (studies) | Proportion |
|---|---|---|
| ***Analysis of crash databases*** | | |
| A re-analysis of officially registered road traffic deaths in Sweden (Ahlm et al., 2001) | Sweden | 3.1% of road traffic fatalities |
| An in-depth investigation of road traffic deaths (Andersson & Sokolowski, 2022) | Sweden | Around 10% of all road traffic fatalities. |
| A re-analysis of national in-depth road crash investigation data by the same research team using the same criteria (Hernetkoski & Keskinen, 1998; Hernetkoski et al., 2001; Hernetkoski et al., 2009, Keskinen & Pasanen, 1990) | Finland | 1.1% (1974–1975), 6.8% (1984–1985), 7.4% (1991–1992); around 8% (1991–1998) of all motor vehicle fatal crashes. |
| A re-evaluation of driver suicides in in-depth fatal crash database (Ohberg et al., 1997) | Finland | 5.9% of all driver fatalities according to the re-evaluation; 7% according to the original data. |
| A retrospective analysis of road suicide involving a passenger car crashing into a heavy vehicle using multidisciplinary investigation data (Radun et al., 2019a) | Finland | The yearly suicide proportion of all motor vehicle fatal crashes varied from 11.2% to 17.6%. |
| A retrospective analysis of all traffic fatalities in a Scotland's region with a focus on suicides (Kuroda & Pounder, 1994). | UK | 1.5% of all road traffic fatalities were suicides. 1.9% of the driver fatalities were suicides. |
| A retrospective analysis of fatal driver crashes using coroner and police reports ( Yelo et al., 2021) | Australia | 2.9% confirmed-by-a-coroner suicides. 4.7% includes also possible suicides. |
| ***Analysis of suicide databases*** | | |
| A retrospective analysis of the national mortality data for completed suicides and hospital data for attempted suicides (Elnour & Harrison, 2008) | Australia | Completed suicide by crashing a motor vehicle: 0.5%; for non-fatal episodes: 0.14%. |
| A retrospective analysis of the national database of forensically investigated suicides (Gauthier et al., 2015) | Switzerland | Road suicides: 1.02% (confirmed)-1.56% (includes also suspected) of ALL suicides. |
| A retrospective analysis of cases extracted from the suicide register in Queensland (Milner & De Leo, 2012) | Australia | Among suicides in the suicide register, 0.5% were drivers using a motor vehicle. |

### 3.6. The proportion of suicides on roads

The proportion of road suicides can be examined from two main perspectives: first, what proportion of all suicides in a country occur on roads, and secondly, what proportion of road fatalities are in fact suicides. Suicide by train is a well-known and studied phenomenon (Krysinska & De Leo, 2008; Too et al., 2014), and it is typically a more prevalent method than road suicides (Airaksinen, Korpinen, & Parkkari, 2016). Therefore, studies analyzing all types of suicide methods often group road suicides together with suicides by train into the joint category of traffic suicides. On the other hand, suicides in road traffic might not be a widely recognized issue for road crash investigators, leading to their poor recognition and consequent underreporting. It is generally believed that road suicides are underreported (e.g., Pompili et al., 2012; Imants et al., 2022).

In between these two approaches (% of all suicides in a country, and % of all road fatalities in a country) comes a body of studies analyzing smaller samples of suicides registered in trauma centers, or those analyzing specific types of road crashes (e.g., single-car, crashes with a heavy vehicle). While these certainly provide valuable information about the prevalence of suicides and their possible underreporting, they do not provide a decisive answer regarding the extent of the road suicide problem.

In Table 2, we summarize the prevalence of road suicides extracted from the studies that utilized national suicide or crash databases. In two of these studies, the crash database covered a large area in a country (eastern Scotland, Kuroda & Pounder, 1994[26]) or a federal state (Queensland in Australia, Milner & De Leo, 2012[29]). The proportion of road fatal crashes/fatalities thought to be suicides varies between 0.5 and ten percent, with the highest proportion of 17.6% recorded in Finland in one year among motor vehicle fatal crashes (Radun et al., 2019a[37]). When specific types of crashes are considered in Finland, such as head-on fatal crashes between light and heavy vehicle that happened in the oncoming vehicle's lane and in which the fatally injured driver of a light vehicle was at fault, the proportion of suicides is as high as 32% (Sassi et al., 2018 [43]).

One of the problems we encountered in our review is when authors report only the proportion of suicides of all fatalities and not of all fatal crashes. Suicides typically involve one fatality (i.e., a person who dies by suicide) while other crashes might involve multiple fatalities. Morild (1994)[30], for example, reported that 3/133 (2.3%) of deaths in their sample were suicides. However, they also reported that 15 deaths came from a single bus accident. If more non-suicide crashes involved multiple deaths, then the proportion of suicide crashes among fatal crashes would be higher than the calculated 2.3%.

### 3.7. Types of crashes

Historically, regarding road suicides, the focus has been on single-vehicle crashes, probably because the purpose of a suicide is typically not to physically endanger someone else although this risk may arise in a head-on crash. Another reason is if a person wants to disguise their suicide, a single crash might be a better option than a crash that involves other participants who, if they survive, might later provide important information about the course of events that led to a collision. It is not surprising, therefore, that one of the three

**Table 3**
Types of road suicides (includes studies with at least 30 road suicides).

| Type of data | Type of suicide crashes |
|---|---|
| A retrospective analysis of driver fatalities, with one focus being on the dentification of suicides (Sweden; Breen et al., 2018). | Single vehicle: 19%; collisions with another vehicle 81%. |
| A retrospective analysis of road suicides identified in the database of forensically investigated suicides (Switzerland; Gauthier et al., 2015). | Unclear, but it seems that at least 24/53 (45%) of confirmed suicides were collisions between motor vehicles, 9 (17%) were pedestrian suicides and the remaining 20 (38%) were presumably single-vehicle crashes. |
| A retrospective analysis of motor vehicle fatalities investigated by multi-disciplinary teams; criteria set by the authors (Finland; Hernetkoski & Keskinen, 1998). | More than 70% of suicides were collisions. |
| A retrospective analysis of motor vehicle fatalities investigated by multi-disciplinary teams; criteria set by the authors (Finland; Hernetkoski et al., 2009). | 73% of suicides were "collisions, typically involving a heavy goods vehicle." |
| A retrospective analysis of motor vehicle fatalities investigated by multi-disciplinary teams; criteria set by the authors (Finland; Keskinen & Pasanen, 1990). | Suicides were mostly collisions (73%). Out of collisions, all but one driver was driving a passenger car and the other party was most frequently (80%) a lorry |
| Descriptive reporting about 40 cases of deliberately caused crashes from own psychiatric practice (US; Macdonald, 1964). | In 10/40 (25%) cases, the suicidal driver crashed into another vehicle. |
| A retrospective analysis of cases extracted from the suicide register in Queensland (Australia; Milner & De Leo, 2012) | In 27.5% of confirmed suicides and 20.7% of possible suicides a person drove into the path of an oncoming truck. Single-car crashes: at least 39.2% of confirmed and 59.6% of possible suicides. |
| A re-evaluation of suicides in in-depth fatal crash database (Finland; Ohberg et al., 1997). | More than 80% of suicides were collisions. |
| A retrospective analysis of road suicide involving a passenger car crashing into a heavy vehicle using multidisciplinary investigation data (Finland; Radun et al., 2019a). | When all suicides were considered (N = 180), 22 (12%) were single-crashes, 138 (77%) involved a passenger car crashing into a heavy vehicle, and the remaining 20 (11%) were other types of collisions. |
| A retrospective analysis of fatal driver crashes using coroner and police reports (Australia; Yelo et al., 2021) | Confirmed suicides: single vehicle: 55%, collisions: 45% (8/10 with a heavy vehicle).<br>Possible suicides: single vehicle: 3/14; collisions: 11/14 (all with a heavy vehicle). |

previous reviews on road suicides focused primarily on single-car crashes (Pompili et al., 2012).

In our review, we found that when all driver suicides are included and types of crashes reported, the proportion of single-car crashes is typically smaller than crashes with an oncoming vehicle (Table 3). Pedestrian suicides were often not included in the reviewed studies. Several studies reported cases of a passenger jumping out of a moving car (Copeland, 1985 [10]), or trying to seize the control of a car (Macdonald, 1964 [27]). However, these seemed to be isolated and rare events similar to complex suicides reported in case studies that were excluded from our review. Complex road suicides possibly have a double purpose: to increase the certainty of dying (e.g., stabbing, or gunshot), which is a typical assumption for complex suicides (Bohnert, 2005; Toro & Pollak, 2009), and simultaneously to disguise suicide in the subsequent crash (Macdonald, 1964 [27]; Morild, 1994 [30]).

In some studies, it was reported that passengers in the suicidal driver's car died (Edland, 1971 [12]; Radun et al., 2019a[37]) or were injured (Copeland, 1985 [10]). However, the circumstances might not always clearly indicate whether the crash was a joint suicide, or whether the driver engaged in a so-called murder-suicide crash (Byard et al., 2018).

### 3.8. The second party

As the previous section shows, driver suicides often include a collision with another vehicle. However, many studies fail to mention what kind of vehicles they were, and especially what happened to the occupants of these vehicles. Several studies only reported that the other vehicles were mostly trucks with or without trailers (Table 3). Breen et al. (2018)[7], for example, reported that in all 30 suicide collisions with another vehicle that they studied, the vehicle had a large mass (lorry, truck, or bus) and Hernetkoski et al., (2009)[19] wrote only that collisions, representing 73% of driver suicides, typically involved "a heavy goods vehicle.".

Table 4 depicts the consequences for the second party in studies that reported such information. Several studies focused completely on the second party (Radun et al., 2021 [34], 2020[35], Radun et al., 2019a[37],Radun et al., 2019b[38],Radun et al., 2019c[36]). They indicate that these crashes can have serious and long-lasting effects on the well-being of drivers involved as the second party. A survey of professional heavy vehicle drivers showed that many perceive road suicides as an occupational risk in their profession (Radun et al., 2019c [36]).

Although several authors have expressed the need to report and analyze the consequences for the second parties (e.g., Gauthier et al., 2015 [14]), this issue has not received much attention. This is rather surprising given the well-known negative psychological consequences of motor vehicle crashes (Marasini et al., 2022), as well as the extensive literature on how train drivers experiencing person-under-train (PUT) incidents cope after these events (Bardon & Mishara, 2015). Moreover, truck drivers are not only more likely to be injured than train drivers in suicide crashes, but there are two psychological mechanisms that can influence their coping after the event. First, compared to the train drivers, truck drivers can do something to prevent the crash (e.g., swerving off the road) and reduce

**Table 4**
Studies that provide information about the consequences for the second party.

| Type of data | Consequences for the second party |
|---|---|
| Fatal crashes documented by the coroner in which motor vehicle passengers or pedestrians died (Canada; Bako et al., 1976) | No motor vehicle occupants were killed in crashes induced by pedestrians. These crashes also included suicide cases. |
| A retrospective analysis of fatal passenger car collisions with another vehicle (Sweden; Björnstig et al., 2008). | Out of 7 verified/strongly suspected and 6 possible suicides with another vehicle, in one case the car driver of the other car also died. |
| A retrospective analysis of road suicides identified in the database of forensically investigated suicides (Switzerland; Gauthier et al., 2015). | In 6/53 (11%) of cases someone else also died. Not reported who and in which vehicle. |
| Analysis of national in-depth road crash investigation data (Finland; Keskinen & Pasanen, 1990). | It was mentioned that of 34 suicides (73% were collisions), a driver died in 33 cases and one survived. This means that at least in one case someone else than the driver died, but it is unclear who that was. |
| A retrospective analysis of all traffic fatalities in one region with a focus on suicides (UK; Kuroda & Pounder, 1994). | Two pedestrian suicides, one single-car and one car-to-car suicide. All four occupants of another vehicle involved in a collision also died. |
| Descriptive reporting about 40 cases of deliberately caused crashes from own psychiatric practice (US; Macdonald, 1964). | Regarding ten crashes with another vehicle, it is only mentioned that "several passengers in other wrecks were less severely injured." |
| A re-evaluation of suicides in in-depth fatal crash database (Finland; Ohberg et al., 1997). | The driver/passenger of the other vehicle died in three of all suicide cases (3.6%). Considering collisions, the percentage is somewhat higher (4.3%). "As a result of the collision, the truck driver usually lost control of his vehicle. In one case, this resulted in the death of the truck driver, and in two other cases, a third vehicle was hit by the swerving and falling truck." |
| An in-depth investigation of 28 consecutive auto fatalities (US; Pokorny et al., 1972). | Four suicides: 3 single-car and one collision with another vehicle. The other driver also died in the only crash involving two vehicles. |
| A semi-structured focus group study with heavy vehicle drivers who experienced a crash caused by a suicidal driver/pedestrian (Finland; Radun et al., 2021) | All six heavy vehicle drivers were uninjured, but report on psychological difficulties following their crashes. |
| A one-year follow-up survey study of professional drivers involved as the second party in road suicides (Finland; Radun et al., 2020). | 10/15 drivers experienced some kind of measurable consequence such as minor physical injuries, sick leaves, posttraumatic stress symptoms, seeking psychological help etc. |
| A retrospective analysis of road suicide involving a passenger car crashing into a heavy vehicle using multidisciplinary investigation data (Finland; Radun et al., 2019a). | Almost 30% of the truck drivers were injured (only 5% of these involved serious injuries). 23.2% of drivers reported sick leave (no info in 71.7% of cases) with a median duration of 14.5 days. |
| An analysis of road traffic deaths at a university forensic unit with the aim of examining the rate and circumstances of suicidal deaths (UK; Wyatt et al., 2009). | The authors report that in 7/17 cases (4 pedestrian and 3 car driver suicides with another vehicle), another person was directly involved. However, no one else was killed or seriously injured. |

its consequences (e.g., hard braking). Feelings of guilt (i.e., "Have I done enough?") were found to be related to the post-traumatic stress symptoms of train drivers involved in PUT incidents (Mehnert et al., 2012). Secondly, given the higher possibility of being injured, truck drivers might experience higher fear and consequent anger when suicidal drivers put their lives at risk (Radun et al., 2021[34]).

### 3.9. Who dies by suicide in road traffic?

#### 3.9.1. Age and gender

In practically all studies, there are more men than women among those who die in road traffic suicides. There are at least three possible reasons for this. First, suicide is much more common in men than women in most countries (World Health Organization, 2019). Second, as mentioned in the introduction, men are more likely to choose more violent methods of suicide. Crashing a vehicle is in that category. Finally, men drive more than women do (Sivak, 2013), so it is possible that extensive driving provides more opportunities for suicidal ideation to be acted upon.

Regarding age, the situation is complex, partly due to the differences in the way information about age distributions are presented. For example, Milner and De Leo (2012)[29] divided ages of individuals into the following groups (under 24, 25–44, 45–64, 65 and above), and reported that the majority (59.3%) of confirmed driver suicides in Queensland, Australia, were in the 25–44 year age group. For non-motor vehicle suicides, the majority (45.1%) of individuals were also in this age group. On the other hand, Ohberg et al. (1997)[32] divided their Finnish sample into somewhat different categories (15–24, 25–34, 35–64, 65 and above), and reported the following percentages among confirmed driver suicides 34.5%, 25%, 39.3%, and 1.2%, respectively. Other studies reported mean age (e.g., 40.5 ± 13.3 years in Breen et al., 2018 [7]; 41.8 years in Gauthier et al., 2015 [14]; 46 years in Wyatt et al., 2009 [49]; 36 years in Truebner et al., 1996 [47]). While there was considerable variation in the way in which ages were grouped in the different studies, the majority of those dying in road suicides were young to middle-aged adults.

#### 3.9.2. Mental health history

It is well known that mental health problems (e.g., depressive symptoms) are associated with suicide (O'Connor et al., 2023). Therefore, it is not surprising that in many of the reviewed studies a significant proportion of those who died by suicide in road traffic were found to suffer from various mental disorders. For example, in a Norwegian study that was specifically conducted to identity suicides among motor vehicle crashes, it was reported that in 30% of "likely suicides", drivers had ongoing or previous psychiatric illnesses (Breen et al., 2018 [7]). Kujansuu et al. (2017)[25] reported that in a sample of fatally injured male drivers with a psychiatric disorder, the proportion of suicides was 19.4% while the corresponding figure among those without such disorder was much lower, at 5.4%.

Among confirmed suicides of drivers in an Australian study, 40.4% of the drivers had made previous suicide attempts, while the corresponding value for possible suicides was zero (Milner & De Leo, 2012[29]). Previous suicide attempts and recent suicidal ideation were important aspects of classification criteria for suicide in some of the reviewed studies (e.g., Andersson & Sokolowski, 2022[2]; Hernetkoski & Keskinen, 1998[17]; Keskinen & Pasanen, 1990[22]). However, the exact prevalence is not always reported.

The major problem here is that given the difficulties in recognizing road suicides (see section 3.5.), investigators and researchers often use any indication of mental health issues and previous suicide attempts to support their initial suspicion that the crash was a suicide. This could lead to circular reasoning. As Keskinen and Pasanen (1990 [17], p.183) wrote: "When the characteristics of the drivers and, for example, their mental state is discussed ……. it must be remembered that many of the characteristics have already been used in the classification. Therefore, the information cannot be of any further support to the classification; it is only meant to describe what kind of groups arose.".

#### 3.9.3. Other background factors

Among other background factors, alcohol use and abuse were often found and noted as possible contributing factors to road suicides. For example, drivers in confirmed driver suicides more often consumed alcohol prior to suicide than those who used other methods of suicide (67.3% vs. 39.5%; Milner & De Leo, 2012[29]). We did not find much information about medication use in relation to this method of suicide; however, the use of psychotropic medication was among grounds for suspicion of suicide in single road fatalities (Connolly et al., 1995[8]). Significant life events, such as the end of a relationship or work, were sometimes noted as potential triggers (e.g., Radun et al., 2007[39]; Wyatt et al., 2009[49]). These factors, however, are typical of any kind of suicide (Favril et al., 2022).

### 3.10. Why people choose this method of suicide

In the identified studies, there was not much information about why and when people chose road traffic as a method of suicide. Studies reporting aggregated data rarely provide information about this, as they typically focused on various background and demographic factors. Better information might come from more detailed case studies; however, as they are isolated cases, they do not allow generalization. Hamburger (1969)[15], for example, reported on the case of a man who considered driving his car off the road at high speed because dying in that way would (a) bring no stigma to his family, (b) bring financial recompense for his family through insurance, and (c) offer a quick way of dying. Many authors have discussed various possible reasons why people choose this method. For example, Macdonald (1964[27], p. 368) wrote that "Wrecking a car at high speed allows violent discharge of very great anger". However, the widespread availability of cars is among the most frequently mentioned factors.

In a survey of Australians who had a history of suicidal ideation and behaviors, 14.6% of those who were planning a suicide had

chosen to crash a motor vehicle (Murray & De Leo, 2007[31]). However, 57.9% of those who attempted but survived their suicide crash reported that they did not want to die, while 42.1% reported their crash was a serious attempt. Since completion of our literature search, a very relevant study has been published (Norman et al., 2023). It showed that the main reasons for considering a vehicle collision by those experiencing suicidal ideation were that it would be quick, impulsive, look like an accident, lethal, easy to do, have minimal physical impact, and be accessible. For those who were considering stepping under a vehicle, the same reasons appeared, although in a somewhat different order and with a lower prevalence for minimal physical impact and for looking like an accident. The prevalence was in this order: quick, lethal, impulsive, easy to do, accessible, and looks like an accident. On the other hand, the most mentioned dissuasive factor against suicide on the roads was its direct impact on other people such as drivers. Radun et al. (2019c[36]) reported the case of a person who died by crashing their car into a heavy vehicle and asked for forgiveness from the driver in a suicide note. Given the possible impact on other people who are directly involved (see section 3.8), it is indeed a relevant question whether those who choose to die in this kind of manner consider the possible harm they might cause to others. Unfortunately, apart from these two studies, we found no relevant information in the literature regarding this question.

Based on the reviewed literature, our view is that the following four main reasons for choosing this method seem to be most plausible: the perceived high lethality of the method; the availability of the means (i.e., motor vehicles) suitable for fast and impulsive enactment; extensive driving provides numerous opportunities for acting upon suicidal ideation; and the possibility of disguising a suicide as a road crash because of the stigma of suicide or the insurance consequences for their family members.

### *3.11. The prevention of road suicides*

Koisaari et al. (2020)[24] examined the potential for contemporary in-car active safety technology to prevent current types of fatal crashes in Finland. They found that suicides are among the causal factors that present the highest challenge for current active safety systems. Environmental interventions, such as physical barriers including central (median) barriers, have been extensively discussed in the literature regarding preventing suicides involving crashes with another vehicle (e.g., Björnstig et al., 2008[6]; Gauthier et al., 2015[14]; Hernetkoski et al., 2001[18]; Okolie et al., 2020; Radun et al., 2019c [36]). However, their potential effects regarding head-on crash suicides are still unknown.

Radun et al. (2019c) [36] reported that in 2004 Finland introduced an addition to the traffic law that obliges medical doctors to notify the police in cases when their patient's "fitness to drive has been compromised in such a way that they could be a threat to themselves or others while driving" (p. 829). The guidelines for assessing a driver's fitness to drive issued by the Finnish Transport and Communications Agency (Traficom) include a reference to people who have a significant and immediate risk of suicide. To the best of our knowledge, the effectiveness of this law in general or regarding prevention of suicide has not yet been evaluated. However, it is known for example that Finnish physicians examining patients who visited a hospital because of alcohol-related ICD-10 diagnosis rarely evaluate their fitness to drive (Kalsi, Tervo, & Tervo, 2019).

In conclusion, the reviewed literature provides little information about the effectiveness of the limited number of possible specific preventive measures for road suicides. Our conclusion coincides with a recent systematic review, which found no studies that examined "the effectiveness of interventions to restrict the availability of, or access to, means of suicide on roads" (Okolie et al., 2020).

### *3.12. An overview of issues regarding quality of studies*

As mentioned, almost all studies were retrospective in nature with the authors usually not being directly involved in collection of the primary data (e.g., road crash and national suicide databases, trauma centers' documentation). This naturally limited them in their analyses making it very difficult to establish the real proportion of road suicides and identify associated background factors. Therefore, the main limitations of the surveyed studies arise from the quality and richness of the primary data. Secondly, the fact that in more than 40% of studies the focus was not primarily on road suicides meant that detailed information for the road suicides was often lacking. In some cases that meant we were able to report only a single piece of information, such as briefly noted proportions of confirmed and possible suicides in fatal crashes that resulted in a burning car (Viklund et al., 2013 [48]). One of the main methodological shortcomings of studies that aimed to identify road suicides by analyzing or re-evaluating crash investigators' or coroners' decisions relates to the lack of clear information whether two researchers independently read each case and discussed possible discrepancies in their evaluations (e.g., Björnstig et al., 2008[6], Breen et al., 2018[7], Connolly et al., 1995 [8], Cooper & Milroy, 1994 [9], Hernetkoski & Keskinen, 1998 [17], Hernetkoski et al., 2001 [18], Hernetkoski et al., 2009 [19], Huusko & Hirvonen, 1988 [20], Kliger & Sporty, 1993 [23]).

It is our view that a thorough multidisciplinary investigation of fatal road crashes including psychosocial examination would result in better recognition of suicides. On the other hand, for attempted road suicides that involve other parties, crash investigators and health professionals could pay more attention to the reasons for choosing this method, given the fact it directly endangers the physical and mental health of others.

## 4. General discussion

We conducted a comprehensive review of the research literature on road traffic suicides. While background and situational factors related to road suicides have been identified to some degree, the question of why some people choose this method of suicide largely remains unanswered despite some recent insightful research (Norman et al., 2023). This poses a challenge for the development of specific preventive measures.

Means restriction is known to contribute to suicide prevention (Lim et al., 2021; Pirkis et al., 2015; Zalsman et al 2016), but this is

difficult to apply directly to prevention of road suicides. One possibility is stopping a person at risk from driving, at least while the recognized suicide risk persists, but a change for such an intervention needs legislation, which may take a while to be implemented. Revoking a driving license is one way of reducing access to the means of suicide (i.e., a motor vehicle) (Radun et al., 2019c [36]). Another way would be advising family members and those close to a person to take the car keys away if the person shows serious signs of suicide intentions, as discussed in Radun et al. (2019c [36]) and also by Schmidt et al. (1972 [45]) more than fifty years ago. This would be similar to recommendations to remove weapons and sharp objects from those who might use them to hurt themselves. However, while it is obvious to anyone that a gun can be used for suicide, crashing a motor vehicle might not be a well-known suicide method. Therefore, some might argue that to take car keys away might inadvertently give an idea to suicidal people how to realize the intention of taking their own life.

On the other hand, means restriction for suicide on roads may include measures which do not require driver compliance (Koisaari et al., 2020[24]; Okolie et al., 2020). Environmental interventions such as central barriers could potentially reduce the number of deliberate head-on crashes. However, the building costs are considerable and might not be easily justified in the context of cost-benefit analysis. Given the extent of road networks with numerous large vehicles moving at high speeds even in urban areas, environmental interventions aimed at reducing pedestrian suicides might be even more difficult to implement. In-vehicle technologies, such as wrong-way driver warning systems might not reduce this kind of suicide, but perhaps would help in distinguishing deliberate from unintentional wrong driving on a motorway. Although there are anecdotal reports of suicides by driving in the wrong direction on a motorway (e.g., Levy, 2009), we did not identify this type of road suicide crash in our review. Similarly, dashboard cameras can help in the decision-making process regarding intentional behavior. For example, Giovannini et al. (2021) reported a case study of a pedestrian crash that was initially assumed to be accidental, and only after the video analysis it was classified as suicide.

Recognizing intentional and self-destructive motives in crash causation remains among the biggest challenges in crash investigations. As mentioned, there are attempts such as a Swedish classification system to improve suicide recognition (Andersson & Sokolowski, 2022[2]). A few years ago, the UK Parliamentary Advisory Council for Transport Safety recommended that [quote]: "A centrally maintained database of suicides and attempted suicides on UK roads [is to] be created" (Harrison, 2017, p.29). Improving the recognition of suicides in road traffic is also necessary for achieving road safety goals, such as the prevention of at least 50% of road fatalities by 2030 adopted by the United Nations General Assembly in their resolution A/RES/74/299 "Improving global road safety" in 2020. If many road suicides remain underrecognized, that will have negative consequences on our understanding when and why some of traditional traffic safety prevention measures work or do not work. The Swedish Transport Administration in their Road Safety Action Plan 2022–2025 has recently specifically mentioned the need of investing in research aimed at understanding of road suicides and committed to "initiate at least five research studies on suicide and suicide prevention in the transport system" (Malmström & Tunmarker, 2023, p. 55).

From a general perspective, effective prevention policies must incorporate a range of measures (Zalsman et al., 2016). General measures for suicide prevention will also be relevant to prevention of road suicides. For example, active follow-up of patients following a suicide-related crisis can help prevent suicidal behavior (Mann, Michel, & Auerbach, 2021). Perhaps, restricting or addressing motor vehicle driving in some way during this follow-up period could be considered. On the other hand, if choosing this method of suicide is motivated by the possible 'benefits' of a disguised suicide (e.g., no disgrace to the family, or no loss of insurance compensation), then a question arises as to whether it is possible to identify individuals at higher risk of choosing this specific method before they act.

Finally, given the enormous investments in traffic safety, for example Vision zero (Kristianssen et al., 2018), an overall improvement in traffic safety will perhaps lead to the de-normalization of road crashes and consequently discourage those who choose this suicide method, because they may want to disguise a suicide as a road crash.

## 5. Strengths and limitations

A strength of our study is that we followed standard methodology for systematic review, with two researchers independently surveying the literature and extracting data. Furthermore, we examined the literature regarding any indication of the consequences suicidal acts on roads may have on possible secondary participants. We excluded 35 studies that indirectly approached the topic of road suicides, such as those that had investigated a possible increase in road crashes following "publicized suicide stories" (e.g., Phillips, 1977). Some of them indirectly suggest that a certain proportion of fatal road crashes might indeed be due to self-destructive actions. We also excluded 32 case studies, which, however, typically offer a great deal of detailed information about suicide crashes as well as situational and background factors leading to them. Finally, several letters to editors and discussion papers were also excluded. We did, however, read these publications and cited some of them, whenever it was deemed useful.

In conclusion, in our systematic review, we have identified 51 studies that provided quantitative information about road suicides. However, road suicide is clearly an area needing more attention in terms of prevalence, and especially causes and consequences, including those for possible secondary participants. Identifying and implementing potential preventive measures for this suicide method merits more attention.

## Author contributions

Conceptualization: I.R., K.H, and T.P.; Methodology: all; Formal analysis: I.R. and P.K.; Writing – original draft: I.R.; Writing-review and editing: all.

## CRediT authorship contribution statement

**Igor Radun:** Conceptualization, Formal analysis, Methodology, Writing – original draft, Writing – review & editing. **Pragathy Kannan:** Formal analysis, Methodology, Writing – review & editing. **Timo Partonen:** Conceptualization, Methodology, Writing – review & editing. **Keith Hawton:** Conceptualization, Methodology, Writing – review & editing.

## Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Extracted data are available in the supplementary file.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.trf.2024.07.028.

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