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NARRATIVE REVIEW

The impact of rurality on child road traffic death in high-income countries

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Abstract

Introduction: Despite the importance of child road traffic death, a limited number of studies have investigated rural child road traffic death in high income countries.

Objective: This review estimated the impact of rurality on child road traffic deaths and other potential risk factors in high-income countries.

Design: We searched Ovid, MEDLINE, CINAHL, PsycINFO and Scopus databases and extracted studies focusing on the association between rurality and child road traffic death published between 2001 and 2021. Available data were extracted and analysed, to evaluate the impact of rurality on child road traffic death and explore other risk factors of child road traffic deaths.

Findings: We identified 13 studies for child road traffic death between 2001 and 2021. Eight studies reported the impact of rurality on child road traffic death, and all of them alleged that the mortality rate and injury rate of children was significantly higher on rural road than on urban road. The impact of rurality varied between studies, from 1.6 times to 15 times higher incidence of road traffic death in rural areas. Vehicle type, speeding cars, driver loss of control, alcohol and drug use road environment were identified as risk factors of child road traffic death. Conversely, ethnicity, seat belts, nondeployed airbag, child restraint, strict driver licence system, camera law and accessibility of trauma centres were considered protective factors. Other factors, including age, gender and teen passengers, appeared ambiguous for child road traffic death.

Discussion: Rurality is one of the most important risk factors of child road traffic death. Therefore, we should consider the impact that rurality has on child road death and resolve the gap between rural and urban areas in order to prevent child road traffic death effectively.

Conclusion: The findings of this literature review will assist policy-makers to prevent child road traffic death by focusing on rural regions.

KEYWORDS

countryside, regional, remote, traffic accident, traffic incidence

1 | INTRODUCTION

Road traffic death is one of the most important causes of death worldwide.[1] Globally, the number of road traffic deaths has increased gradually from 2000 to 2016 and reached 1.35 million in 2016. Furthermore, road traffic injuries are reported as the eighth leading cause of death for all age groups.[1] Children are particularly vulnerable to road traffic deaths than adults, given that their physical, cognitive and social capabilities are not fully developed.[2] Road traffic deaths ranked among the top four causes of death for all children over the age of 5 years in 2012, with 186 300 children dying from road traffic crashes around the world.[2] Hence, there is a need to differentiate road traffic deaths between adults and children to prevent child road traffic death effectively.

In August 2020, the UN General Assembly adopted a resolution for the Decade of Action for Road Safety 2021–2030, also referred to as 'Improving global road safety', with the ambitious target of preventing at least 50% of road traffic deaths and injuries by 2030.[3] In the same resolution, implementation of road safety polices for the protection of vulnerable group among road users, such as children, youth, older persons and people with disabilities, was strengthened.

There is a strong association between the risk of a road traffic death and the income level of countries. The risk is more than three times higher in low-income countries, where the average rate is 27.5 deaths per 100 000 population than in high-income countries, where the average rate is 8.3 deaths per 100 000 population.[1] However, traffic death is also an important cause of death in high-income countries (HICs), with mortality rates of 15.6 and 9.3 deaths per 100 000 population in Europe and America, respectively.[1]

In Australia, the number of child road traffic deaths decreased steadily from 2010 to 2019.[4] However, traffic road deaths ranked the top causes of death for children aged 0–16 years, and second for those aged 17–25 years from 2016 to 2018.[5] Therefore, child road death is an important cause of death among children in Australia.

Rurality has also been considered as a significant risk factor of road traffic deaths across the globe.[6] A study in Italy over the period of 1991–1996 showed the mortality rate of traffic accidents among pedestrians, car drivers, moped and bicycle riders was higher outside the urban centre,[7] and a study in Austria between 1980 and 2012 showed that about three quarters of traffic fatalities occurred in municipalities with less than 20 000 inhabitants.[8] Additionally, a study in Australia between 2007 and 2016 showed that the crude rate per 100 000 population of child and adolescent fatality caused by land transport injuries was higher in inner region (RR: 2.55; 95% CI: 1.86–3.48), outer region (RR: 3.01; 95% CI: 2.06–4.38), remote (RR: 4.39; 95% CI: 2.17–8.89) and very remote (RR: 5.87; 95% CI: 2.83–12.18) compared with major city areas.[6]

A number of literature reviews focused on children's injuries or traffic road death in rural areas.[9,10] Collectively, these literature reviews showed that the number of child mortality rate was higher in rural areas. However, although road traffic deaths are significant causes of child deaths in HICs and the rate of deaths on roads increases as you move rurally, few review papers have been published that explored studies on rural child road deaths in HIC. To provide a better understanding on child road traffic death and to contribute to the development of child road traffic death prevention in rural areas, we implemented a systematic literature review aimed at exploring rural child road fatalities in HICs in rural areas over a 20-year period.

What is already known on this subject?

- The risk of road traffic death is substantially higher in lower-income countries, although road traffic death is still highly prevalent in high-income countries.
- Children are particularly vulnerable to road traffic incidence than adults, with rurality considered a strong risk factor of road traffic death.
- While several review papers have focused on children's road traffic death in rural areas, no review papers have reported on these statistics in high-income countries.

What does this study add?

- According to this review, several studies reported that the mortality rate of children was significantly higher in rural road than on urban road in high-income countries.
- Although vehicle type, speeding cars, driver loss of control, alcohol and drug used on road were also identified as risks for child road traffic death, factors underpinning the distinction in the mortality of children between rural and remote roads are still unclear in high-income countries.
- Future research should explore potential reasons differentiating the mortality of children between rural and remote roads to assist in reducing rural traffic incidence among children in high-income countries.

2 | MATERIALS AND METHODS

2.1 | Literature search

We searched Ovid MEDLINE, CINAHL, PsycINFO (ProQuest) and Scopus databases for all relevant studies published between 18 March 2001 and 18 March 2021. We used a set of key words in order to extract studies, which met our objective. The set of key words included 'children', 'traffic accident', 'high income countries', 'death' and 'rural'.

2.2 | Eligibility criteria

The inclusion criteria for this review were the following: (i) published within the last 20 years; (ii) peer-reviewed journal articles; (iii) original research paper; (iv) full-text available; (v) published in English; (vi) took place in Australia, Canada, the USA, New Zealand, Japan and the United Kingdom; and (vii) child (<20 years) road traffic death. We selected six countries from high-income countries because these six countries' situation is similar to each other. The exclusion criteria were the following: (i) non-peer-reviewed journal or other type of publications; (ii) comprehensive scientific reviews, meta-analysis, statements of clinical standards, case reports, opinion pieces; (iii) took place in countries except for Australia, Canada, the USA, New Zealand, Japan and the United Kingdom; and (iv) adult (over 20 years) road traffic death. For the purpose of this review, children were classified as people who were aged less than 20 years.

2.3 | Data collection process

First, potential abstracts were assessed for inclusion and to determine retrieval of full-text articles that met the inclusion criteria. Second, full-text articles were accessed and checked whether the study consisted of quantitative data regarding child road traffic death in rural areas. For each study, we assessed data on the distribution of child road traffic death and the association between child road traffic death and rurality. Studies not meeting this quality assessment were excluded. Available data from all selected studies were extracted and stored in a spreadsheet. For each study, data on the country, study period, study design, study setting, age, study design, data source, outcome measure, road user type and case definitions were extracted (Table 1). To evaluate the influence of rurality on child road traffic death, the data on age group, gender, rurality, risk of rurality, definition of rurality and the information of other risk factors, except for rurality, were also extracted and stored (Tables 2 and 3).

3 | RESULTS

3.1 | Characteristics of studies

According to the PRISMA flowchart (Figure 1), the review identified 13 studies for child road traffic death between 2001 and 2021. Ten studies were conducted in the USA,[11–20] two were conducted in Canada,[21,22] and one study was conducted in Australia.[23] Seven studies focused on children under 14 years,[11,13,14,16,17,20,23] and four studies focused on adolescent individuals over 14 years.[12,15,18,19] Twelve studies were retrospective and registry-based studies,[11,12–17,19–23] one study was a prospective and population-based study,[18] and the other study employed a cross-sectional and population-based approach.[19] These studies were based on data collected between 1992 and 2017, and the study period ranged from 1 to 14 years, with a mean of 7.15 years. More than half of the studies[11,15–17,19,20,23] were conducted after the year 2000, with eight studies focusing on death,[11,12,17,18,20–23] two studies on fatal crash,[13,14] two studies on death and disabling injuries[15,16] and one study on injurious crash.[19] The number of child road traffic deaths or injuries was between 19 and 27 913 (mean: 4236.8). The characteristics of the studies are summarized in Table 1.

3.2 | Trend over time of child road traffic death

Chang[23] reported that the child road death decreased from 2001 to 2012, and Hamann et al.[19] reported that injury crashes decreased from 190 in 2001 to 107 in 2003 in Iowa among adolescent drivers aged 14–15 years (Table 2).

3.3 | The impact of rurality on child road death

Eight studies reported the impact of rurality on child road traffic death,[13–15,17–21] and all of them alleged that the mortality rate and injury rate of children was significantly higher on rural road than on urban road. The study conducted by Kmet et al. (2006)[21] in Canada reported that the relative risk (RR) of child road death in the rural areas was 5.4 (95% CI: 4.2, 6.9) compared with the urban areas, and Mokdad et al. (2020)[20] reported the OR of child road death in the USA was 1.60 (95% CI: 1.27, 2.01) in micropolitan and 2.33 (95% CI: 1.85, 2.91) in noncore. Wolf et al.[17] reported that for each 1% increase in the percentage of crashes occurring on rural roads, the percentage of children that died increased by 0.05% (95% CI: 0.01, 0.09). Frinsch[13] reported that child road fatal crashes were 15

TABLE 1 Child road traffic death studies published between 2001 and 2021.

Reference	Study period	Study setting	Age	Study design	Study type	Data source	Outcome measure	Case definition	Road user type
11	2002	USA	0–14	Retrospective	Registry-based	FARS	Death	Deaths within 30 days of a crash	Pedestrian
21	1997–2002	Alberta/CAN	0–19	Retrospective	Registry-based	Alberta Collision Information System	Death	Deaths within 30 days of a crash	NA
12	1992–2002	USA	15–17	Retrospective	Registry-based	FARS	Death	Deaths within 30 days of a crash	NA
13	1994–2004	Texas/USA	7–11	Retrospective	Registry-based	FARS	Fatal crash	Deaths within 30 days of a crash	Driver
14	1999–2003	USA	7–14	Retrospective	Registry-based	FARS	Fatal crash	Deaths within 30 days of a crash	Driver
15	2001–2007	USA	14–17	Retrospective	Registry-based	State crash files	Death and disabling injuries	Crash categorized as fatal or injury	Driver
22	1998–2011	Alberta/CAN	0–19	Retrospective	Registry-based	OCME	Death	Coded manually reviewed by OCME staff	Cyclist
16	2005–2007	USA	0–14	Retrospective	Registry-based	NHTSA-SDS	Death and disabling injuries	Injuries categorized by police as incapacitating or fatal	Occupant
17	2010–2014	USA	0–14	Retrospective	Registry-based	FARS	Death	Deaths within 30 days of a crash	NA
23	2001–2012	Victoria/AUS	0–14	Retrospective	Registry-based	NCIS	Death	Deaths by external cause on road	Passenger
18	1999–2005	USA	15–17	Prospective	Population-based	FARS	Death	Deaths within 30 days of a crash	NA
19	2001–2003	Iowa/USA	14–15	Cross-sectional	Population-based	Iowa Department of Transportation	Injurious crash	Motor vehicle crashes resulted in death, injuries and property damage greater than $1500	Driver
20	2010–2017	USA	0–14	Retrospective	Registry-based	FARS	death	Deaths within 30 days of a crash	NA

Abbreviations: FARS, Fatality Analysis Reporting System; NCIS, National Coronial Information System; NHTSA-SDS, National Highway Traffic Safety Administration State Data System; OCME, Office of the Chief Medical Examiner.

TABLE 2 Rural child road traffic death and impact of rurality of child road traffic death.

Reference	*N*	Trend	Age group	Gender	Rurality	Impact of rurality	Definition of rurality
11	402	NA	0–14; 402	NA	Rural; 402	NA	Population
21	383	NA	0–14; 100 15–19; 283	Male; 53 Female; 47 Male; 183 Female; 100	Urban; 16 Rural; 84 Urban; 56 Rural; 227	Rural; 5.4 (95% CI: 4.2–6.9) (RR)	Population densities
12	528	NA	15–17; 528	NA	Rural; 528	NA	Population and incorporation
13	51	NA	7–14; 51	NA	Urban; 18 Rural; 33	Crash rate in rural is 15 times higher than in urban	RUCC
14	350	NA	7–14; 350	Male; 66% Female; 34%	Urban; 32% Rural; 68%	Correlation between crash rate & rurality (R = 0.561)	RUCC
15	195	NA	14–17; 195	NA	NA	Rural; 5.818 (95% CI: 4.010–8.440) (OR)	NA
22	19	NA NA	0–9; 7 10–19; 12	Male; 4 Female; 3 Male; 12 Female; 0	Urban; 4 Rural; 3 Urban; 7 Rural; 4 Unknown; 1	NA	Legal limit
16	8738	NA	0–14; 8738	NA	Urban; 1332 Rural; 7406	NA	RUCC
17	2885	NA	0–14; 2885	NA	NA	Increase of 1% in rural crashes see a 0.05% increase in AAMR	Federal Highway Authority
23	107	Downward trend	0–4; 38 5–9; 29 10–14; 40	NA NA NA	Urban; 8 Rural; 30 Urban; 4 Rural; 25 Urban; 4 Rural; 36	NA	NA
18	27913	NA	15–17; 27913	Male; 60.9% Female; 38.9%	Urban; 38.94% Rural; 61.96%	Rural road associated with increased crude mortality	NA
19	1824	190 (2001) to 107 (2013)	14–15; 1824	NA	Urban; 813 Suburban; 110 Town; 598 Remote rural; 303	Suburban; 1.06 (95% CI: 0.94–1.12) (Rate ratio) Town; 1.44 (95% CI: 1.33–1.55) Remote rural; 1.64 (95% CI: 1.51–1.77)	UIC
20	9271	NA	0–14; 9271	Male; 56% Female; 44%	Metropolitan; 38% Nonmetropolitan; 62%	Nonmetropolitan; 1.60–2.33 (OR)	2013 National Center for Health Statistics' Urban–Rural Classification Scheme for Counties

Abbreviations: AAMR, age-adjusted, motor vehicle crash-related mortality rate per 100000 children; OR, odds ratio; RR, relative risk; RUCC, Rural–Urban Continuum Codes; UIC, Urban Influence Codes.

TABLE 3 Risk/protective factors for child road traffic death except for rurality.

Risk/protective factors	Definition and description	References
Age	Mortality rate is higher among 15–19 years compared to 0–14	21
	Mortality rate is higher among younger drivers	15
	Mortality rate of passenger and pedestrian among 0–4 years old is the highest between 0–14 years old	23
Gender	Mortality rate is higher among men	21
	Injury rate is higher among women (Note when modelled)	15,19
Race	The mortality rate of Hispanic is lower than not Hispanic	18
Seat belts	The usage of seat belt decreases mortality rate	15
	Strict seat belt law decreases mortality rate	18
Nondeployed airbag	The mortality rate is lower in crashes where airbag is not deployed	18
Child restraint	The usage of child restraint decreases mortality rate	17
Vehicle type	Mortality rate of pedestrians hit by bus, motorcycle and light truck is higher than hit by car	11
	Driving minivan increase mortality rate	18
Speed of car	Speed in excess of 144.84 kph (90 mph) increase mortality rate	18
Driver loss of control	Driver loss of control increases injury rate	19
Teen passenger	Having teen passengers in car increase injury rate	19
	Having teen passengers in car decrease injury rate	15
Alcohol or drug use	Alcohol and drug use of young driver increase severe injuries	15
Road environment	Dry surface condition increases mortality rate	18
GDL programmes	Strong programmes intended to phase in young novice drivers to full licensure decrease mortality rate	12,14,18
Camera law	Red light and speed camera laws decrease mortality rate	18
Accessibility of trauma centres	Accessibility of trauma centres decreases mortality rate	18,20

times higher on rural road compared with urban road in Texas. Vachal et al.[15] reported that the OR of child road death and disabling injuries was 5.82 (95% CI: 4.01, 8.44). Hamman et al.[19] reported that the rate ratio of injurious crash was 1.06 (95% CI: 0.86, 1.26) in suburban, 1.44 (95% CI: 1.33, 1.55) in town and 1.64 (95% CI: 1.51, 1.77) in remote rural. The impact of rurality is summarized in Table 2.

3.4 | Other risk or protective factors for child road traffic death

Some studies reported other risk or protective factors of child road death and injurious crashes. Characteristics of road user such as age, gender and race may serve to protect, or exert risks for, child road death. One study[18] reported that the mortality rate of Hispanic was lower. Two studies[15,17] reported that using safety tools, such as seat belts or child restraint, were protective factors of child road death. Additionally, other studies reported that the mortality rate of crashes with nondeployed airbag, or when cars were driven at a lower speed, was lower.[18] Studies have also mentioned that the behaviour or environment of drivers served to protect, or exert risks for, child road death. One study[19] reported that loss of control during driving was a risk factor of child road death, while another study[15] reported that alcohol or drug use increased severe injuries of young drivers. Another study[18] reported that dry surface conditions on the road increased mortality rate. Interestingly, one study[19] reported that the presence of teen passengers in the car increased injury rate of children, but another study[15] reported that it decreased injury rate. In addition, the strict regulation, such as good adherence to driving licence of young drivers and strict red light and speed camera laws, decreased mortality rate.[12,14,18] Moreover, good accessibility to trauma centres decreased mortality rate of children.[18,20]

4 | DISCUSSION

This review demonstrated that child road death was higher on rural roads than in urban areas, with several reasons reported by authors of studies that were included in the current review. First, some studies alleged that the use of

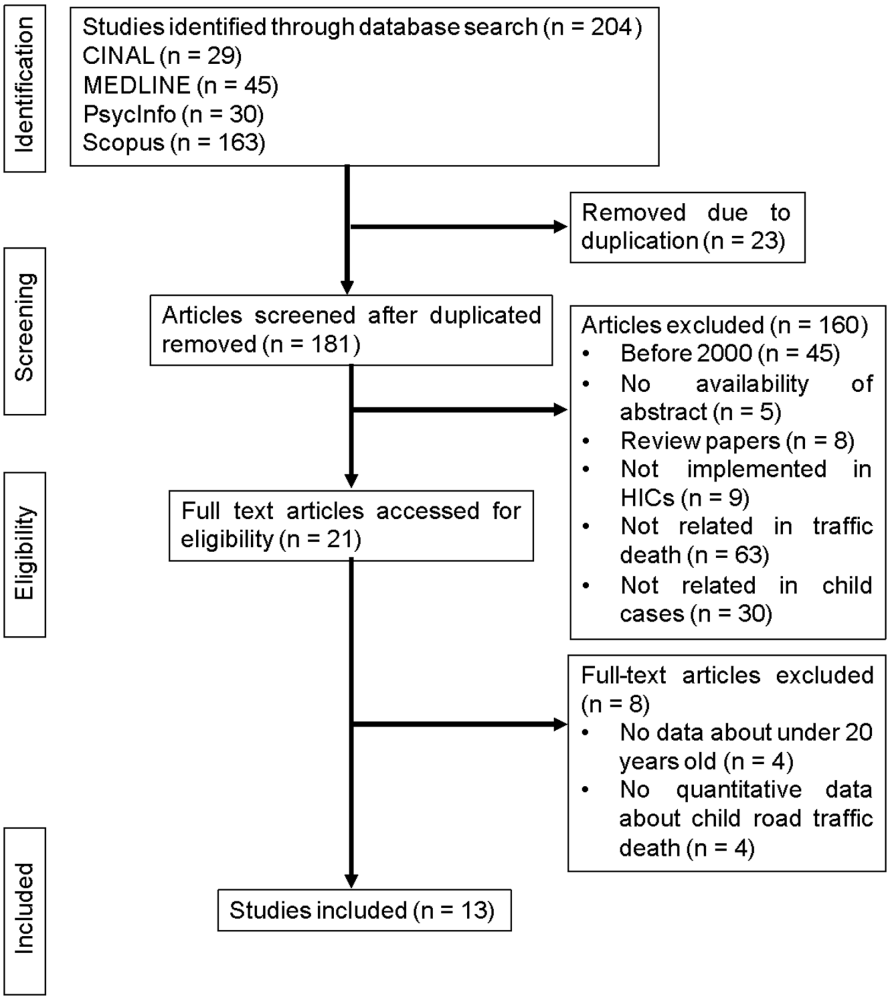

FIGURE 1 PRISMA flowchart: Selection of studies for child road traffic death between 2001 and 2021.

safety tools, such as seat belt or child restraint, decreased the mortality rate of children on the road.[15,18] Beck et al.[24] reported that the proportion of occupants who were unrestrained at the time of the fatal crash increased as rurality increased in the United States. Therefore, increasing the proportion of unrestrained drivers or occupants in rural areas may increase the rate of child road traffic death. Second, the study conducted by Kallail et al.[25] reported that the proportion of young unlicensed drivers involved in fatal crashes was significantly higher in rural counties than in urban counties in Kansas. In addition, in the same study, young unlicensed drivers tended not to use safety restraint compared with licensed drivers. In this review, adherence to driver licence was one risk factor of child road death,[12,14,18] while poor adherence to driver's licence laws was considered as a potential cause of child road traffic death in rural areas. Thirdly, different environments on the road were identified as another potential reason for child road traffic death. Notrica et al.[18] reported that dry surface on the road caused increasing traffic death. Therefore, the lack of pavement or loss of control on the road in rural areas may increase child road traffic death. Finally, two studies reported that the accessibility to trauma centres was also a risk factor of child road traffic death.[18,20] Hence, the lack of immediate treatment of victims on road due to poor accessibility to hospital or trauma centre may increase child road traffic death.

Although several reasons were identified as potential causes of child road death, a number of studies also reported conflicting findings. First, one study reported that mortality rate was higher among 15–19 years compared with 0–14 years,[21] but mortality rate was higher among the younger group in two other studies.[15,23] Kmet and colleagues[21] focused on all road user type, while Vachal et al. (2009)[15] and Change et al.[23] focused on drivers and passengers. Thus, the difference in road user type may explain why the impact of age was distinct between these studies. Second, a study reported that the mortality rate of males was higher than females,[21] but two other studies reported that the injury rate of females was higher than males.[15,19] In general, boys account for nearly twice as many road traffic deaths as girls worldwide.[2] However, some studies reported that females have a greater likelihood of serious injury controlling for other crash factors.[26,27] Evans[26] reported that the fatality risk of females from similar physical impact was higher than males in traffic accident, so

females may be more vulnerable to physical impact and this vulnerability may explain that females have greater likelihood of serious injury. Third, Hamman et al.[19] reported that having teen passengers in a car increased the injury rate, and these results were consistent with other reports.[28,29] However, Vachal et al.[15] reported conflicting findings among teen passengers, and the authors speculated that the injury rate may have been lower in teen passengers as they were relatives rather than friends. Therefore, Vachal and colleagues[15] postulated that the passenger factor may increase the teenagers' sense of responsibility or that they were less likely to fall asleep or be distracted by using a cell phone.

4.1 | Strength and limitations

Previously, some articles explored the association between rurality and road traffic death, but these studies focused mainly on adults and there were only a few studies that reported the association between rurality and child road death. Therefore, this review clarified that rurality was one of the most significant risk factors of child road death. Additionally, from our review, even in high-income countries, there was a clear distinction between urban and rural child road death, and thus, it is essential to minimize this gap to effectively reduce the prevalence of child road traffic death. Therefore, findings of this literature review are helpful for policy-makers to prevent child road traffic death because they can focus on rural areas.

However, a number of limitations should be noted for this review. First, some studies focused on death, others focused on fatal crashes, and others focused on injurious crashes or severe injuries, so the results of these studies were different in each study. Furthermore, the method to evaluate the association between rurality and child road death was different in each study. Some studies reported OR, and other studies reported rate ratio. Additionally, the definition of rural area was distinct in each paper. Therefore, we were not able to compare or combine the result of these studies directly in this review due to a certain degree of heterogeneity in the methodological approach between studies.

5 | CONCLUSION

This study has explored the impact of rurality on child road traffic death in high-income countries. This study identified that rurality is one of the most significant factors of child road traffic death, demonstrating that child road traffic accident is an important cause of death, even in HICs. Thus, we should consider potential factors underpinning the influence that rurality has on child road death and resolve the gap between rural and urban areas to prevent child road traffic death effectively. More studies are necessary to clarify the difference between rural and urban child road traffic death in the future.

AUTHOR CONTRIBUTIONS

Soonho Koh: Conceptualization; investigation; methodology; writing – original draft; formal analysis; data curation. **Kenji Doma:** Conceptualization; investigation; methodology; writing – review and editing; formal analysis; data curation; supervision. **Richard Franklin:** Conceptualization; investigation; methodology; writing – review and editing; formal analysis; data curation; supervision.

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CONFLICT OF INTEREST STATEMENT

The authors do not declare any conflict of interest.

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