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Global trends in adolescents' road traffic injury mortality, 1990–2019

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ABSTRACT

Objective The aim of this study was to determine the trends of road traffic injury (RTI) mortality among adolescents aged 10–14 years and 15–19 years across different country income levels with respect to the type of road users from 1990 to 2019.

Methods We conducted an ecological study. Adolescents' mortality rates from RTIs at the level of high-income countries (HICs), upper-income to middle-income countries (UMICs), lower-income to middle-income countries and low-income countries were extracted from the Global Burden of Disease study. Time series were plotted to visualise the trends in mortality rates over the years. We also conducted Poisson regression using road traffic mortality rates as the dependent variable and year as the independent variable to model the trend of the change in the annual mean mortality rate, with incidence rate ratios (IRRs) and 95% CIs.

Results There were downward mortality trends in all types of road users and income levels among adolescents from 1990 to 2019. HICs had more pronounced reductions in mortality rates than countries of any other income level. For example, the reduction in pedestrians in HICs was IRR 0.94 (95% CI 0.90 to 0.98), while that in UMICs was IRR 0.97 (95% CI 0.95 to 0.99) in adolescents aged 10-14 years.

Conclusions There are downward trends in RTI mortality in adolescents from 1990 to 2019 globally at all income levels for all types of road users. The decrease in mortality rates is small but a promising finding. However, prevention efforts should be continued as the burden is still high.

What is already known on this topic?

- Road traffic injuries (RTIs) are the most common cause of death in adolescents.
- Globally, pedestrians and car occupants account for the majority of RTI mortality in adolescents.
- The current literature on RTIs in adolescents is mostly from high-income countries (HICs).

What this study adds?

- A downward trend of road traffic mortality rates in adolescents is observed at all income levels from 1990 to 2019, but the magnitude varies by type of road user, income level and age group.
- HICs have a larger reduction in mortality rates for all types of road users compared with any other income level.
- The difference in mortality burden between two age groups of adolescents is larger in motorised vehicles (motor vehicles and motorcyclists) versus non-motorised vehicles (pedestrians and cyclists) due to the high burden in adolescents aged 15–19 years compared with those aged 10–14 years.

INTRODUCTION

The global mortality rate due to road traffic injuries (RTIs) has plateaued since 2007 and has shown a slight reduction since 2013.[1–6] High-income countries (HICs) have experienced a larger reduction than lower-income to middle-income countries (LMICs).[7] Motor vehicle users predominate among fatalities in HICs, while pedestrians, motorcyclists and cyclists account for most deaths in LMICs.[3]

RTIs are the leading cause of death worldwide among children and young adults aged 5–29 years, third among adolescents aged 10–14 years and first among adolescents aged 15–19 years.[8–10] The current literature on RTI mortality in adolescents is mostly based on HICs and specific geographical regions.[11–13] This literature largely combines data on both children and adolescents and shows that pedestrians and car occupants account for the majority of RTI mortalities.[14]

The burden and causes of RTI mortality are, however, likely to be different in children than in adolescents. Children may unintentionally be involved in risks on the road, whereas adolescents tend to indulge in risk-taking behaviours.[12] The mortality rates due to RTIs are reported to decline in both the 10–14 years and 15–19 years age groups, with a variation in the magnitude of the reduction in deaths across geographical locations.[10 15]

There are several gaps in the current literature. First, the variations in road user-specific mortality rates among adolescents are not known according to the income level of countries. Second, trends in adolescents' mortality among different types of road users over the years are unknown; therefore, it is critical to know the context of countries' income level. The trend of mortality rate by road user type will help contextualise problems and design local evidence-based interventions.

The aim of this study was to determine the trends of RTI mortality among adolescents aged 10–14 years and 15–19 years across different country income levels with respect to the type of road users from 1990 to 2019.

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METHODS

Study design

We conducted an ecological study.

Setting

We extracted global and income-level country mortality rates of RTIs from the Global Burden of Disease (GBD) study by the Institute of Health Metrics and Evaluation from 1990 to 2019,[16] categorising the income levels as high-income countries (HICs), upper-income to middle-income countries (UMICs), lower-income to middle-income countries (LMICs) and low-income countries (LICs). It is important to highlight that the income level of countries was not static over the years, and there has been an increase in the number of countries labelled HICs and subsequently a decrease in LICs since 1993.[5]

Variables

We used yearly estimates of mortality rates of RTIs per 100 000 people in adolescents aged 10–14 years vs 15–19 years for analysis. We had road user types as all road users, pedestrians, cyclists, motorcyclists and motor vehicle users. All road injuries included 'other road users', in addition to the four abovementioned categories. 'Other road users' are road users that cannot be classified as any of the aforementioned four types, such as riders of animals or occupants of animal-drawn vehicles injured in road crashes.[16]

Data sources/measurement

The GBD study uses multiple data sources, including vital registration, verbal autopsy, mortality surveillance, censuses, surveys, hospitals, police records and mortuaries, to calculate mortality estimates. The GBD study assesses data quality, including completeness, missing data rates and accuracy, and then applies sophisticated modelling strategies to capture patterns in the data and to reduce estimation error. The modelling of these data has been defined in greater detail in previous publications.[17]

Analyses and statistical methods

All statistical analyses were conducted using R. Descriptive statistics are reported as mean rates with SD. Time series were plotted with the y-axis on the non-linear log scale to visualise the trends in mortality rates over the years. We also conducted Poisson regression with a log link to quantify the percentage change in the rate per year. The road traffic mortality rate was the dependent variable, and year was the independent variable. Income level, road user type and age were used to stratify the model. We report the model coefficients and incidence rate ratios (IRRs) with 95% CIs.

RESULTS

There were 1500 data points in this analysis from five country income groups, five road user types and a span of 30 years for two age groups.

From 1990 to 2019, the mean mortality rate for all road users was higher among adolescents ages 15–19 years than among those aged 10–14 years at all income levels except that the mean rates of cyclist injuries were comparable in both age groups. In HICs, the highest mean mortality rate for motor vehicle injuries was 11.7 (SD 3.9) vs 1.7 (SD 0.6) in the age groups of 15–19 years and 10–14 years, respectively. The difference in motorcycle injuries was also large between the two age groups; the mean mortality rates were 4.1 (SD 0.4) and 4.5 (SD 0.3) in adolescents aged 15–19 years vs 0.6 (SD 0.1) and 0.7 (SD 0.1) in those aged 10–14 years in LMICs and LICs, respectively.

For all income levels, the mean mortality rates were highest for motor vehicle injuries in adolescents aged 5–19 years except in LICs, where the mean mortality rate for pedestrian injuries was the highest. In adolescents aged 10–14 years, the highest mean mortality rates were of pedestrian injuries in all income levels, with the exception of motor vehicle injuries in HICs (table 1).

The time-series plots in figure 1 show slight downward trends in the mortality rate of all types of road users from 1990 to 2019 for adolescents aged 15–19 years and 10–14 years. The downward trend is more pronounced in HICs for all types of road users compared with other income levels.

The mortality rates for 15- to 19-year-olds were higher than those for 10- to 14-year-olds for all types of road users and country income levels. Within facet differences in mortality rate trends between the two age groups were larger for motor vehicle users and motorcyclists than for pedestrians and cyclists in all country income groups and even more so in HICs.

At the same time, the trends in the two age groups were parallel at all income levels for all road users, showing constant differences in the rates in both age groups. The trends were not parallel for cyclists in HICs. The trends in motorcycle and motor vehicle users in UMICs, LMICs and LICs were close to static, particularly in the age group of 15–19 years. The trends in cyclists were irregular in LMICs and LICs in both age groups.

The IRRs for all road user groups in all locations for both age groups showed annual decreases in mortality rates with only

Table 1 Descriptive statistics, as the mean (SD) of the road mortality rate of years 1990–2019 by type of road user and country income level for adolescents by age groups (n=30)

		Road user type				
Income levels	**Age (years)**	All road users	Pedestrians	Cyclists	Motorcyclists	Motor vehicle road users
Global	15–19	15.3 (2.3)	4.5 (0.9)	0.7 (0.1)	3.9 (0.4)	6.2 (1.0)
	10–14	5.8 (1.1)	2.8 (0.7)	0.4 (0.1)	0.6 (0.1)	1.9 (0.2)
High-income countries	15–19	17.3 (6.0)	2.2 (0.8)	0.5 (0.2)	2.8 (1.2)	11.7 (3.9)
	10–14	3.6 (1.5)	1.2 (0.6)	0.5 (0.2)	0.2 (0.1	1.7 (0.6)
Upper-income to middle-income countries	15–19	17.4 (1.7)	6.3 (0.9)	0.6 (0.1)	2.0 (0.2)	8.5 (0.6)
	10–14	7.7 (0.8)	3.6 (0.5)	0.3 (0.1)	0.6 (0.1)	3.2 (0.2)
Lower-income to middle-income countries	15–19	13.1 (1.6)	3.4 (0.6)	0.6 (0.1)	4.1 (0.4)	4.8 (0.6)
	10–14	5.2 (0.8)	2.5 (0.4)	0.4 (0.1)	0.6 (0.1)	1.7 (0.2)
Low-income countries	15–19	16.8 (2.0)	6.0 (1.3)	0.7 (0.1)	4.5 (0.3)	5.4 (0.5)
	10–14	6.8 (1.4)	3.7 (1.0)	0.5 (0.1)	0.7 (0.1)	1.8 (0.3)

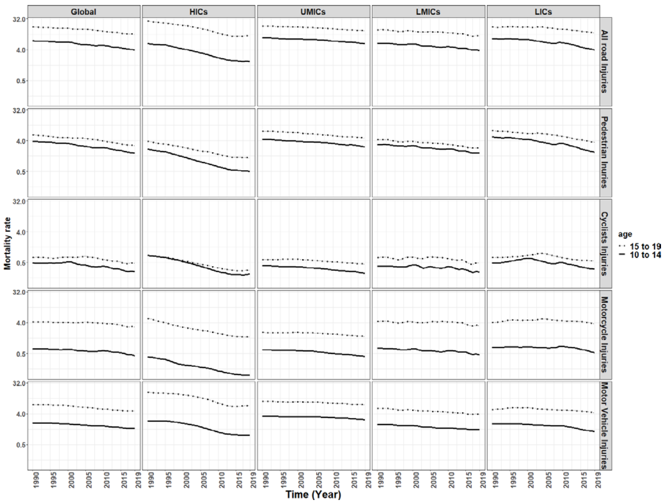

Figure 1 Time-series plots for mortality rates per 100 000 of different types of road users aged aged 10–14 years and 15–19 years by country income groups, 1990–2019. HIC, high-income country; LIC, low-income country; LMICs, lower-income to middle-income countries; UMICs, upper-income to middle-income countries.

one exception: motorcyclists aged 15–19 years in UMICs had no change in annual mortality rates (IRR 1.00, 95% CI 0.98 to 1.02). All types of road users had more reduction in the rates in HICs compared with any other income group (tables 2 and 3).

DISCUSSION

To the best of our knowledge, this study is the first on RTI mortality with a focus on adolescents aged 10–14 years and 15–19 years by type of road user and country income level. Our study shows downward trends in RTI mortality in adolescents from 1990 to 2019 for all road users globally and for all country income levels. HICs have more prominent downward trends than all other income levels. The rates are higher in adolescents aged 15–19 years for all road users in all income groups, with much difference in rates between the two age groups for motor vehicle users and motorcyclists compared with pedestrians and cyclists. The burden of mortality rate also varies by road users in income groups; pedestrians' burden is highest in LICs and motor vehicles in HICs. In UMICs and LMICs, motor vehicles are present in adolescents aged 15–19 years, and pedestrians are present in adolescents aged 10–14 years.

A global reduction in road traffic mortality in all age groups was observed between 2007 and 2010, but with disparities across countries.[2] The downward trends in RTI mortality rates in HICs have been known since at least the late 1960s to 1970s.[18] HICs have achieved the greatest gains in RTI prevention, most likely by implementing a combination of multisectoral strategies.[5 19] In addition, there has been a striking increase in mortality due to RTIs in LMICs. Overall, the agenda of injury prevention and control has gained momentum in the last few decades and has also been observed for other types of injuries, including falls, drowning, fire and poisoning.[20] Some recent studies have also indicated a decrease in RTI mortality in specific age groups, such as those under 5 years, 0–14 years and 0–19 years.[10 15 21] These studies reported decreasing rates at the global level or at the level of geographical regions or compared the 'LMICs' with the 'HICs', and the years being compared also varied.

The reduction in adolescent RTI mortality rates in LMICs may be due to a series of changes to the benefit of many road users, which are already present in HICs. Advances in road infrastructure, the implementation and enforcement of safety legislation, and progress in emergency trauma care may have contributed. Additionally, the type and duration of traffic exposure of adolescents have been reduced through decreased walking and independent commuting,[22 23] and the protection of potential victims has been enhanced through vehicle safety and protected gears.[24 25] The aforementioned factors, consisting mainly of measures targeting road users of all ages, have also benefited adolescents. Nonetheless, many measures, such as separate cycle lanes, zebra crossings, priority traffic rules for vulnerable road users and traffic calming around schools and residential areas, are still uncommon in LICs. For example, only 6% of LICs have applied helmet best practices, including for child/adolescent passengers on motorcycles.[4] Moreover, the decrease in mortality rate should also be cautiously interpreted in countries where data coverage is low.

While the decrease in road traffic mortality rates is a success, much more is required to achieve global targets. The Stockholm declaration in 2020 calls for a new global target of reducing road traffic injuries and deaths by 50% by 2030.[26] Even successful road safety interventions are still not implemented in the majority of countries. Political influence is required for the uptake of safety strategies for road safety. The Stockholm declaration calls for strengthening all five pillars of the Global Plan for the Decade of Action: better road safety management; safer roads, vehicles and people; and enhanced postcrash care.[27]

The burden of RTIs varies by road users across different income levels. The burden of mortality due to motor vehicles is high in HICs in both age groups. It is also high in UMICs and LMICs for adolescents ages 15–19 years. The majority of the world population and vehicles are in middle-income countries (MICs) and HICs. Approximately 76% and 15% of the world's population lives in MICs and HICs, respectively, and the corresponding portions of registered vehicles are 59% and 40%, respectively.[4] UMICs and LMICs have a high burden of pedestrians in adolescents aged 10–14 years. LICs have a high burden of pedestrian

Table 2 Poisson regression of road traffic mortality rates and years (1990–2019) by type of road user and country income level in adolescents 15–19 years of age

	Road users				
Income levels	All road injuries IRR (95% CIs)	Pedestrian injuries IRR (95% CIs)	Cyclist injuries IRR (95% CIs)	Motorcyclist injuries IRR (95% CIs)	Motor vehicle injuries IRR (95% CIs)
Global	0.98 (0.97 to 0.99)	0.98 (0.96 to 1.00)	0.99 (0.94 to 1.04)	0.99 (0.97 to 1.01)	0.98 (0.97 to 1.00)
High-income countries	0.96 (0.95 to 0.97)	0.96 (0.93 to 0.99)	0.96 (0.90 to 1.02)	0.96 (0.93 to 0.98)	0.96 (0.95 to 0.98)
Upper-income to middle-income countries	0.99 (0.98 to 1.00)	0.98 (0.96 to 0.99)	0.99 (0.94 to 1.04)	1.00 (0.98 to 1.02)	0.99 (0.97 to 1.01)
Lower-income to middle-income countries	0.99 (0.98 to 1.00)	0.98 (0.96 to 1.00)	0.99 (0.94 to 1.04)	0.99 (0.97 to 1.01)	0.99 (0.97 to 1.01)
Low-income countries	0.99 (0.98 to 1.00)	0.98 (0.97 to 1.00)	0.99 (0.93 to 1.05)	0.99 (0.96 to 1.02)	0.99 (0.98 to 1.01)

IRR, incidence rate ratio.

Table 3 Poisson regression of road traffic mortality rates and years (1990–2019) by type of road user and country income level in adolescents 10–14 years of age

	Road users				
Income levels	All road injuries IRR (95% CIs)	Pedestrian injuries IRR (95% CIs)	Cyclist injuries IRR (95% CIs)	Motorcyclist injuries IRR (95% CIs)	Motor vehicle injuries IRR (95% CIs)
Global	0.98 (0.96 to 1.00)	0.97 (0.95 to 1.00)	0.98 (0.92 to 1.05)	0.99 (0.94 to 1.04)	0.99 (0.96 to 1.02)
High-income countries	0.95 (0.93 to 0.98)	0.94 (0.90 to 0.98)	0.95 (0.88 to 1.01)	0.95 (0.86 to 1.04)	0.96 (0.93 to 0.99)
Upper-income to middle-income countries	0.98 (0.96 to 0.99)	0.97 (0.95 to 0.99)	0.99 (0.93 to 1.04)	0.99 (0.95 to 1.04)	0.98 (0.95 to 1.02)
Lower-income to middle-income countries	0.98 (0.97 to 1.00)	0.98 (0.95 to 1.01)	0.99 (0.92 to 1.06)	0.99 (0.94 to 1.04)	0.99 (0.96 to 1.02)
Low-income countries	0.99 (0.97 to 1.00)	0.98 (0.96 to 1.01)	0.98 (0.91 to 1.06)	0.99 (0.93 to 1.04)	0.99 (0.97 to 1.02)

IRR, incidence rate ratio.

mortality for both age groups. While the infrastructure of the road environment in HICs facilitates safe walking and cycling, this is not the case for some MICs and most LICs. The planning of road safety is influenced by evidence tested mostly in HICs.[28] However, the variation in burden by road users calls for specific context-based interventions in countries.

Higher rates in adolescents aged 15–19 years could be explained by increased road traffic exposure at this age due to the increased independence they obtain in mobility without adult accompaniment. Their commuting expands from being pedestrians, cyclists and passengers to drivers of motorcycles and other motor vehicles,[29] leading to a larger difference between rates of adolescents aged 15–19 years vs 10–14 years within motorcyclists and motor vehicle users at all income levels. Undoubtedly, risk-taking behaviour increases the chances of road crashes, but not just that. A better understanding of the unique relationship between adolescents and the transport system is determined by the confluence of multiple factors dictated by the practical needs of mobility and the physical and mental development of adolescents. A societal expectation for increased mobility, a lack of access to safer transportation options, and a perception that motor vehicles are a source of recreation, independence and prestige determine this complex relationship. Policies that influence societal norms and expectations in the local road safety context need further development. Exploring the influence of mainstream and social media, safe role models, and changing normative behaviour require specific strategies for the adolescent age group.

The study highlights some critical areas for adolescents' road safety that have implications. When the two age groups are combined within the larger category of children, the unique challenges and opportunities to address road traffic injuries in these groups are lost. Policies such as graduated licensing,[30] restriction in night-time driving[31] and mobility management (intervention that promotes walking, cycling and public transport instead of private cars)[32] might be effective and need broad implementation after testing for effectiveness in specific contexts. Additionally, the emphasis on teen drivers to obtain valid licences may help in their understanding of rules and regulations related to driving. Safe commuting of adolescents as pedestrians and cyclists is a daunting task and needs proper road infrastructure planning and resources, but has the potential to save many preventable deaths and could encourage healthy living for many generations to come.

Limitations

A first limitation is the merged data of motor vehicles, as they included both three-wheelers and four-wheelers, which hinder our comparison and conceal the burden by individual vehicle type. The clear majority in this category were four-wheelers, as the overall use and mortality rate of three-wheelers are very low. Second, the coverage of mortality data for road injuries could be under-reported for LMICs. Nevertheless, GBD was modelled to predict the estimates by capturing all sources of uncertainty level, and the reporting might have improved over the years. Third, the threshold for World Bank classification of the world's economies has been annually adjusted for inflation, so the number of countries in each category continues to change each year. A high number of countries would have been at a low-income level in the 1990s compared with recent years. However, this annual reclassification is applicable for all four income levels and is an inherent feature of this classification.

CONCLUSIONS

There has been a downward trend in adolescents' mortality due to RTIs over the period 1990–2019 for all country income levels for pedestrians, cyclists, motorcyclists and motor vehicle users. The downward trend in mortality rates is a promising finding in all income levels, but this finding should not relax prevention efforts, particularly in MICs and LICs, because the burden is still at an alarming level. Furthermore, the trends and risks for RTI mortality should always be studied with respect to specific age groups and road users; for example, in the case of adolescents, those who are adolescents aged 10–14 years- vs 15–19 years have unique challenges.

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Contributors URK conceptualised and drafted the study. URK, JAR and MGW developed the research objective. MGW supervised all analysis. MGW and JR critically reviewed all the drafts.

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Competing interests None declared.

Patient consent for publication Not required.

Ethics approval Ethical clearance for this study was not required, as it uses secondary data from the Global Burden of Disease, which are publicly available.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. Data are available upon reasonable request. The study data are taken from Global Burden of Diseases data and have also been uploaded in GitHub (https://github.com/martingerdin/Paper-1).

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REFERENCES

1 James SL, Lucchesi LR, Bisignano C, *et al*. Morbidity and mortality from road injuries: results from the global burden of disease study 2017. *Inj Prev* 2020;26:i46–56.
2 Ning P, Schwebel DC, Huang H, *et al*. Global progress in road injury mortality since 2010. *PLoS One* 2016;11:e0164560.
3 WHO. *Global status report on road safety 2013: supporting a decade of action: summary*. World Health Organization, 2013.
4 WHO. *Global status report on road safety 2018: summary*. World Health Organization, 2018.
5 WHO. *Global status report on road safety 2015*. World Health Organization, 2015.
6 GBD 2015 Eastern Mediterranean Region Transportation Injuries Collaborators. Transport injuries and deaths in the eastern Mediterranean region: findings from the global burden of disease 2015 study. *Int J Public Health* 2018;63:187–98.
7 Haagsma JA, Graetz N, Bolliger I, *et al*. The global burden of injury: incidence, mortality, disability-adjusted life years and time trends from the global burden of disease study 2013. *Inj Prev* 2016;22:3–18.
8 Global Burden of Disease Child and Adolescent Health Collaboration, Kassebaum N, Kyu HH, *et al*. Child and adolescent health from 1990 to 2015: findings from the global burden of diseases, injuries, and risk factors 2015 study. *JAMA Pediatr* 2017;171:573–92.
9 Global Burden of Disease Pediatrics Collaboration, Kyu HH, Pinho C, *et al*. Global and national burden of diseases and injuries among children and adolescents between 1990 and 2013: findings from the global burden of disease 2013 study. *JAMA Pediatr* 2016;170:267–87.
10 Li Q, Alonge O, Hyder AA. Children and road traffic injuries: can't the world do better? *Arch Dis Child* 2016;101:1063–70.
11 Al-Hajj S, El Bcheraoui C, Daoud F, *et al*. Child and adolescent injury burden in the eastern mediterranean region: Findings from the Global Burden of Disease 1990-2017. *BMC Public Health* 2020;20:1–10.
12 Peden M, Oyegbite K, Ozanne-Smith J. *World report on child injury prevention*. Geneva: World Health Organization, 2009.
13 Sethi D. *European report on child injury prevention*. WHO Regional Office Europe, 2008.
14 Alonge O, Hyder AA. Reducing the global burden of childhood unintentional injuries. *Arch Dis Child* 2014;99:62–9.
15 Göpfert A, Sethi D, Rakovac I, *et al*. Growing inequalities in child injury deaths in Europe. *Eur J Public Health* 2015;25:660–2.
16 Murray CJL, Ezzati M, Flaxman AD, *et al*. GBD 2010: design, definitions, and metrics. *Lancet* 2012;380:2063–6.
17 Murray CJ, Lopez AD, Mathers CD, et al. *The global burden of disease 2000 project: aims, methods and data sources*. Geneva: World Health Organization, 2001: 36. 1–57.
18 Borowy I. Road traffic injuries: social change and development. *Med Hist* 2013;57:108–38.
19 Salam RA, Arshad A, Das JK, *et al*. Interventions to prevent unintentional injuries among adolescents: a systematic review and meta-analysis. *J Adolesc Health* 2016;59:S76–87.
20 Wang H, Bhutta ZA, Coates MM, *et al*. Global, regional, National, and selected subnational levels of stillbirths, neonatal, infant, and under-5 mortality, 1980-2015: a systematic analysis for the global burden of disease study 2015. *Lancet* 2016;388:1725–74.
21 Huang Y, Wu Y, Schwebel D, *et al*. Disparities in under-five child injury mortality between developing and developed countries: 1990–2013. *Int J Environ Res Public Health* 2016;13:653.
22 Shaw B, Bicket M, Elliott B. *Children's independent mobility: an international comparison and recommendations for action*, 2015.
23 Kyttä M, Hirvonen J, Rudner J, *et al*. The last free-range children? Children's independent mobility in Finland in the 1990s and 2010s. *J Transp Geogr* 2015;47:1–12.
24 Violence WHODo, Prevention I, Violence WHO. *Global status report on road safety: time for action*. World Health Organization, 2009.
25 Giles-Corti B, Vernez-Moudon A, Reis R, *et al*. City planning and population health: a global challenge. *Lancet* 2016;388:2912–24.
26 Stockholm Declaration on road safety, 2020. Available: https://www.roadsafetysweden.com/about-the-conference/stockholm-declaration/
27 World Health Organization. *Global Launch: decade of action for road safety 2011-2020*. World Health Organization, 2011.
28 Evaniew N, Godin K, Schemitsch EH, *et al*. Evidence gaps in the global decade of road traffic safety. *J Orthop Trauma* 2014;28 Suppl 1:S15–17.
29 Clifton KJ. Independent mobility among teenagers: exploration of travel to after-school activities. *Transportation Research Record* 1854;2003:74–80.
30 Bates LJ, Allen S, Armstrong K, *et al*. Graduated driver licensing: an international review. *Sultan Qaboos Univ Med J* 2014;14:e432.
31 Lin M-L, Fearn KT. The provisional license: nighttime and passenger restrictions--a literature review. *J Safety Res* 2003;34:51–61.
32 Ward A, Lewis SR, Weiss H. Mobility management to prevent, reduce, or delay driving a car in teenagers. *Cochrane Database Syst Rev* 2020;8:CD009438.