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A systematic review of the evidence for effectiveness of interventions to address transport and other unintentional injuries among adolescents

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ABSTRACT

Introduction: Globally, injuries are a leading cause of mortality and morbidity for adolescents, which disproportionately affect the disadvantaged. To build an investment case for adolescent injury prevention, evidence is needed as to effective interventions. *Methods:* A systematic review of peer-reviewed original research published between 2010–2022 was conducted. CINAHL, Cochrane Central, Embase, Medline and PsycINFO databases were searched for studies reporting the effectiveness of unintentional injury prevention interventions for adolescents (10–24 years), with assessment of study quality and equity (e.g., age, gender, ethnicity, socio-economic status). *Results:* Sixty-two studies were included; 59 (95.2%) from high-income countries (HIC). Thirty-eight studies (61.3%) reported no aspect of equity. Thirty-six studies (58.1%) reported prevention of sports injuries (commonly neuromuscular training often focused on soccer-related injuries, rule changes and protective equipment). Twenty-one studies (33.9%) reported prevention of road traffic injury, with legislative approaches, commonly graduated driver licensing schemes, found to be effective in reducing fatal and nonfatal road traffic injury. Seven studies reported interventions for other unintentional injuries (e.g., falls). *Discussion:* Interventions were strongly biased towards HIC, which does not reflect the global distribution of adolescent injury burden. Low consideration of equity in included studies indicates current evidence largely excludes adolescent populations at increased risk of injury. A large proportion of studies evaluated interventions to prevent sports injury, a prevalent yet low severity injury mechanism. Findings highlight the importance of education and enforcement alongside legislative approaches for preventing adolescent transport injuries. Despite drowning being a leading cause of injury-related harm among adolescents, no interventions were identified. *Conclusion:* This review provides evidence to support investment in effective adolescent injury prevention interventions. Further evidence of effectiveness is needed, especially for low- and middle-income countries, populations at increased risk of injury who would benefit from greater consideration of equity and for high lethality injury mechanisms like drowning.

1. Introduction

Globally, injuries are the leading cause of death in adolescents aged 10–24 years, claiming more lives than communicable or non-communicable diseases (Ward et al., 2021). In 2019, two-fifths (40.9%) of all deaths among adolescents were due to injuries, whether intentional or unintentional (Ward et al., 2021). Transport and unintentional injuries accounted for over half of this burden (24.8%). Injuries also cause significant health-related disability, which can have lifelong impacts (McGee, Sethi, Peden, & Habibula, 2004). Despite this, injury among adolescents has

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received far less policy and programmatic focus than injury-related harms in young children and adults (Rivara, 2012; Patton et al., 2012).

Recent data from the Global Burden of Disease Study 2019 indicate that over the past 30 years, the proportion of all-cause deaths and disability adjusted life years (DALYs) from transport and other unintentional injuries in adolescents has remained largely unchanged (Peden et al., 2022). Furthermore, earlier gains in reducing adolescent transport and other unintentional injury have stalled in high-income countries, while fatal and nonfatal injury represent a growing burden in low- and middle-income countries (Ward et al., 2021; Peden et al., 2022).

Within individual countries, there is a clear socioeconomic gradient evident in injury-related harms; people who are more socioeconomically disadvantaged have a higher rate of injury and poorer outcomes (Haagsma et al., 2020; Williams et al., 1997). Socioeconomic factors such as lower neighborhood and family income, unemployment, geographical remoteness, and low parental education (Remes et al., 2019; Yuma-Guerrero et al., 2018; Goldman et al., 2018; Peden and Franklin, 2021) have all been found to be positively correlated with increased injury-related mortality and morbidity for adolescents. There is also a greater burden of injury in low- and middle-income countries and among First Nations populations in high-income countries (Vecino-Ortiz et al., 2018; Sleet, 2018). Equity is therefore appreciated as an important consideration when developing, implementing, and evaluating injury prevention interventions (Ryder et al., 2020).

To reduce and prevent transport and other unintentional injury-related harms for adolescents, investment is vital. However, to be most effective, investment should target evidence informed preventive interventions. Of concern, previous research suggests there is limited evidence of effective interventions for adolescents (Salam et al., 2016). The primary aim of this systematic review was to identify and report the evidence for the effectiveness of interventions to address transport and other unintentional injuries among adolescents aged 10–24 years worldwide. A secondary aim, given the socio-economic gradient for injury (Haagsma et al., 2020), was to assess the evidence with respect to considerations of equity.

2. Methods

A full systematic review (without meta-analysis) of the peer-reviewed literature was conducted in accordance with the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) statement (LA Moher, Tetzlaff, & Altman, 2009) to identify studies reporting interventions addressing unintentional injury among adolescents. The protocol for this review was prospectively registered with PROSPERO (#CRD42020218967).

2.1. Search strategy and eligibility criteria

Searches for peer-reviewed literature published in English between 1st January 2010 and 31st March 2022 were conducted across CINAHL, Cochrane Central, Embase, Medline (ePub), Medline (Ovid) and PsycINFO databases. Search strategies involved a mix of subject headings and keywords to identify literature reporting the population of interest, relevant injury mechanisms, the intervention and the outcome of interest (Table 1). Search terms varied across databases on the advice of research librarians after detailed consultations and to also match database requirements. The full search strategy can be found in Table S1.

Studies eligible for inclusion were peer-reviewed original research (i.e., excluding literature reviews and meta-analyses) with an exclusive focus on, or separate reporting of data for the prevention of transport or unintentional injury in adolescents aged 10–24 years old (inclusive) in the community (i.e., not clinical or incarcerated populations). The age range of 10–24 years was chosen to reflect adolescent growth and popular understandings of this life phase (Sawyer, Azzopardi, Wickremarathne, & Patton, 2018), as well as the significant, yet neglected injury burden among this age group. Studies were also included if the mean age of participants fell within this age range (i.e., <25 years). Intentional and self-inflicted injuries were excluded. All transport and unintentional injuries were included aside from: self-reported injuries (i.e., injuries reported by the adolescent themselves, as opposed to a health professional, in order to indicate some measure of severity [i.e., clinical diagnosis or medical system treatment]); injuries resulting from poisoning from food, medicines and drugs that were ingested intentionally or through medical or surgical intervention; concussion (as a secondary injury due to an initial head injury); and sunburn (due to likely not requiring medical system diagnosis or treatment).

Table 1
Example of search terms.

Category	Example terms
Population of interest	children or youth* or adolescent* or "young adult" or "young adults" or "young person" or "young persons" or "young people
Relevant injury mechanisms	(vehicle or car or traffic or transport or cycl* or pedestrian or boat*), (collision* or crash* or accident* or injur*), (falls or "fall injury" or "fall injuries" or drowning or burns or "burn injury" or "burn injuries" or "electric shock" or "heat injury" or "heat injuries" or "cold injury" or "cold injuries" or poisoning)
The intervention	intervention* or countermeasure* or deterrence or preventive or preventative or prevention or program
Outcome of interest	injury or injuries or "physical disability" or hospitali?ation or mortality or fatality or "quality of life" or QOL or well#being

Types of studies to be included were: cluster randomized controlled trials (RCT) and other RCTs; case control or cohort studies; crossover trials; non-randomized trials; case series with pre-post or post-test outcomes; quasi-experimental designs; observational studies; mixed methods studies; and cost-effectiveness/ cost-benefit/ cost-utility studies.

Prevention interventions were included if they targeted adolescents, parents, caregivers, teachers, or coaches. Secondary or tertiary prevention interventions (i.e., interventions aimed at preventing re-injury or improving treatment or quality of life after injury) and interventions that reported on behavioral or attitude change, rather than reported on fatal or nonfatal injuries were excluded. Studies were included if interventions addressed the outcomes of death or nonfatal injury (defined as any interaction with the healthcare system within 12 months of the initial injury and/or one day or more off usual activities such as work, school, or sport). Studies reporting interventions with outcomes related to sport conditioning or improving sport functioning or performance, as opposed to outcomes with respect to injury were excluded. Similarly, studies reporting the enforcement of interventions or the prevention of incidents (i.e., the outcome of interest being car crashes as opposed to crash-related hospitalized injury) were excluded. The full eligibility criteria can be found in Table S2.

2.2. Literature screening and data extraction

Retrieved citations were exported into Covidence for screening (Veritas Health Innovation, 2021). Independent dual screening of 20% of studies by title and abstract followed by full text screening was undertaken by authors BB and LT. Conflicts were resolved by a third reviewer (AP). Independent data extraction was conducted by both authors (BB, LT), with dual extraction of 20% of included studies (AP, HM, and AW). Reference and citation searches of included papers were conducted, as was reference checking of excluded literature reviews and meta-analyses.

Data extraction was performed using a custom-built Microsoft Excel spreadsheet. Data extracted included study design, study population and sample size, injury mechanism addressed (coded to ICD-10 categories of injury (World Health Organization, 2020), outcome or measures of effect, intervention type, intervention setting and intervention effectiveness (direction/magnitude of effect for each outcome by age, sex and any other relevant variable). Where studies reported intentional and unintentional injuries (i.e., unintentional and intentional firearm injuries) only data related to unintentional injuries were extracted and reported. Income levels of countries represented in included studies were assessed when completing the review using World Bank open data country profiles (The World Bank, 2022).

2.3. Assessment of literature

Included studies were assessed against the Australian National Health and Medical Research Council's (NHMRC) Levels of Evidence (Australian Government National Health and Medical Research Council (NHMRC), 2005). Levels of evidence range from Level I (a systematic review of Level II studies [randomized controlled trials]) to Level IV (case studies with either post-test or pre-test/post-test outcomes) (Australian Government National Health and Medical Research Council (NHMRC), 2005).

The methodological quality of included studies was assessed using the appropriate Johanna Briggs Institute (JBI) critical appraisal checklist based on study type (Aromataris, 2020). This was done independently by two authors (BB and LT) with 20% dual screening (AP, HM, AW). Checklists provide a score based on assessment of a range of study design components. The threshold for inclusion was a combined score of 5 or more. Given the inequitable burden of injuries worldwide (Haagsma et al., 2020), specific attention was paid to issues of equity within the identified studies. Equity was assessed using PROGRESS Plus (i.e., factors such as place of residence, education, socio-economic position, age, disability, sexual orientation among others) and displayed as a modified four-level rating as detailed by Ryder et al (Ryder et al., 2020), ranging from 1-not at all evident (no consideration or discussion of equity) to 4 – highly evident.

3. Results

3.1. Description of study characteristics

A total of 15,374 studies were identified across the database searches. After removal of duplicates (n = 3,909), 11,465 studies were screened for inclusion by title and abstract. Of these, 11,014 studies were deemed irrelevant. A total of 451 full text studies were screened for eligibility. After the removal of 389 studies at full text review, a total of 62 studies were included for data extraction (Fig. 1).

Of the 62 included studies (Achenbach et al., 2018; Åkerlund et al., 2020; Åkerlund et al., 2022; Anderson et al., 2017; Baker et al., 2016; Barboza et al., 2019; Bello et al., 2011; Berecki-Gisolf et al., 2001–2017. 2020,; Bollars et al., 2014; Bonne et al., 2018; Chena et al., 2019; Collard et al., 2010; Conner and Smith, 2017; Cusimano et al., 2011; Edwards et al., 2013; Ehsani et al., 2014; Emery et al., 2022; Emery et al., 2021; Emery et al., 2020; Fell et al., 2011; Fell et al., 2014; Ferdinand et al., 2015; Foss et al., 2018; Gatterer et al., 2012; Grooms et al., 2013; Hägglund et al., 2013; Hasebe et al., 2020; Hassan et al., 2017; Hirschberg and Lye, 2020; Inada et al., 2019; Ji et al., 2017; Kaafarani et al., 2015; Keall et al., 2015; Kiani et al., 2010; Kliethermes et al., 2019; Kosola et al., 2016; Krist et al., 2013; Krutsch et al., 2020; Lacny et al., 2014; Layba et al., 2017; Longo et al., 2012; Males, 2013; Marshall et al., 2016; McGuine et al., 2011; Mendez-Rebolledo et al., 2021; Myers and Lehna, 2017; Nauta et al.,

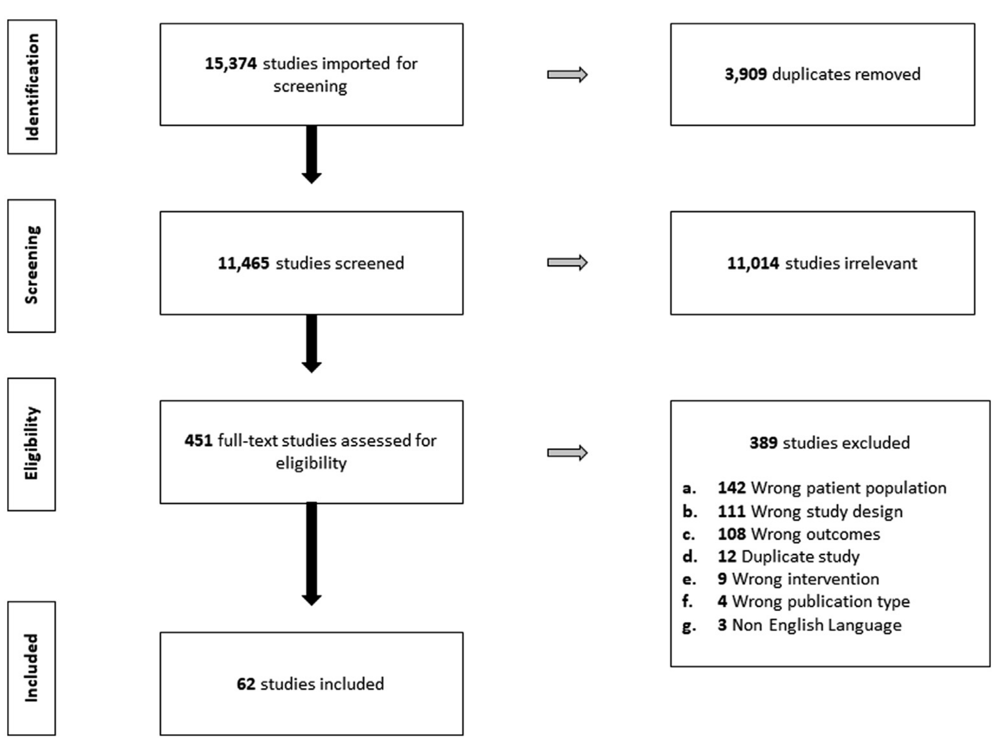

Fig 1. PRISMA flow chart.

2013; Owoeye et al., 2014; Reinold et al., 2018; Richmond et al., 2016; Richmond et al., 2016; Rouse et al., 2013; Scherer et al., 2015; Sherk et al., 2018; Silvers-Granelli et al., 2018; Slauterbeck et al., 2019; Steffen et al., 2013; Tashiro et al., 2016; Toledo et al., 2012; Waldén et al., 2012; Whalan et al., 2019; Zarei et al., 2020), 19 unique countries were represented, most notably the United States (US, n = 23 studies; 37.1% of all studies) followed by Canada (11 studies; 17.7%), and Sweden (n = 5; 8.1%). The bulk (95.2%; n = 59) of studies were from high-income countries. When assessed against NHMRC level of evidence criteria, there were no level I studies (i.e., a systematic review of randomized controlled trials). Nineteen studies were ranked as level II (randomized controlled trials; 30.6% of included studies). A low proportion (n = 5, 7.8%) ranked as level IV (case studies with either post-test or pre-test/post-test outcomes; all from the US and Canada). The full study characteristics of each of the included studies can be found in Table S3.

Sixty percent of all studies (61.3%; n = 38) were rated as having no consideration or discussion of equity. Against the PROGRESS Plus framework, the most commonly reported variables were age (n = 54; 87.1%) and gender (n = 42; 67.7%). The full equity assessment using PROGRESS Plus can be found in Table S4. No studies evaluated injury prevention interventions for First Nations adolescents.

Among the included studies there were 25 (40.3%) RCTs, 15 (24.2%) cohort studies and 11 (17.7%) quasi experimental studies (Table S5). Included studies most commonly described interventions to reduce sports injury (36 studies; 58.1% of included studies), followed by road traffic injuries (21 studies; 33.9%). Three studies (4.8%) evaluated fall prevention interventions and two examined burn prevention (Table 2).

3.2. Sports injury

There were 36 (58.1%) studies that reported interventions to reduce sports injury among adolescents, all from high-income countries. The level of evidence was quite high for sports injury prevention interventions; 47.2% of studies (n = 17) were assessed as evidence level II (Table 3).

The most common sport reported was soccer (football) (50.0%; n = 18) and interventions were most commonly neuromuscular training (generally for warm up), rule modification (commonly body checking [i.e., when a defensive player crashed into an opponent using the hip or shoulder] policies in Ice Hockey), and protective equipment (Table 3).

With respect to neuromuscular training, the most commonly reported interventions were various iterations of the International Federation of Association Football (FIFA) neuromuscular training program (i.e., FIFA 11, FIFA 11+, FIFA 11 + Kids). This program was generally found to be effective for preventing a range of injuries including lower extremity injuries, knee injuries, and training injuries. Effectiveness was enhanced with higher compliance with the program (Hägglund, Atroshi, Wagner, & Waldén, 2013). Neuromuscular training was also found to lower injury risk associated with basketball (Emery et al., 2021; Foss et al., 2018; Longo et al., 2012), field hockey (Barboza et al., 2019), handball

Table 2
Studies evaluating injury prevention interventions by injury mechanism, country, and country World Bank income level as at 2022 (N = 62).

Injury type	Country (Reference)	World Bank Income level	Total number of studies	% of total studies
Burns	Canada (Richmond et al., 2016) US (Myers & Lehna, 2017)	High	2	3.2
Falls	Canada (Sherk et al., 2018) The Netherlands (Nauta et al., 2013) New Zealand (Keall et al., 2015)	High	3	4.8
Firearm-related injuries	US (Tashiro et al., 2016)	High	1	1.6
Road traffic injuries	Australia (Hirschberg & Lye, 2020) Canada (Richmond et al., 2016; Sherk et al., 2018) China (Ji et al., 2017) Finland (Kosola et al., 2016) Israel (Toledo et al., 2012) Japan (Inada, Tomio, Nakahara, & Ichikawa, 2019) UK (Edwards et al., 2013) US (Anderson et al., 2017; Bonne et al., 2018; Conner and Smith, 2017; Ehsani et al., 2014; Hassan et al., 2017; Kaafarani et al., 2015; Layba et al., 2017; Males, 2013; Rouse et al., 2013; Scherer et al., 2015; Fell et al., 2011; Fell et al., 2014; Ferdinand et al., 2015)	High	21	33.9
Sports injuries	Australia (Whalan, Lovell, Steele, & Sampson, 2019) Belgium (Bollars et al., 2014) Canada (Cusimano et al., 2011; Lacny et al., 2014; Marshall et al., 2016; Richmond et al., 2016; Steffen et al., 2013; Emery et al., 2022; Emery et al., 2021; Emery et al., 2020) Chile (Mendez-Rebolledo et al., 2021) Germany (Achenbach et al., 2018; Krutsch et al., 2020) Italy (Gatterer et al., 2012; Longo et al., 2012) Japan (Hasebe et al., 2020) The Netherlands (Barboza et al., 2019; Collard et al., 2010; Krist et al., 2013) Spain (Chena, Rodríguez, Bores, & Ramos-Campo, 2019) Sweden (Åkerlund et al., 2020; Åkerlund et al., 2022; Hägglund et al., 2013; Kiani et al., 2010; Waldén et al., 2012) UK (Longo et al., 2012) US (Baker et al., 2016; Foss et al., 2018; Grooms et al., 2013; Kliethermes et al., 2019; McGuine et al., 2011; Reinold et al., 2018; Silvers-Granelli et al., 2018; Slauterbeck et al., 2019)	High	36	58.1
	Brazil (Bello, Mesiano Maifrino, Gama, & Rodrigues de Souza, 2011)	Upper middle		
	Iran (Zarei et al., 2020)	Lower middle		
	Nigeria (Owoeye, Akinbo, Tella, & Olawale, 2014)			
Unintentional injuries	Australia (Berecki-Gisolf et al., 2001–2017. 2020)	High	1	1.6

Note: Some studies dealt with multiple injury mechanisms. Abbreviations: UK = United Kingdom; US = United States of America.

Table 3
Injury prevention interventions for adolescent sports injury (n = 36).

Sport (reference)	Evidence level	Type of injury	Intervention	Age group (years)	Outcome/Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
American football (Baker et al., 2016)	III-3	Shoulder	Shoulder stabilising braces	18–22	Rate of injury	↓*	Lower posterior labral tear injury rates for those who wore shoulder braces RR = 0.46 (95% CI, 0.16–1.30; P = 0.14)
					Time missed (practice or game)	↓*	Less time missed with brace use (8.7 vs 36.60 games and practices missed due to shoulder injury; P = 0.002)
					Tear requiring surgery	-	No significant difference in shoulder labral tears requiring surgery was found for brace use vs no brace use
Baseball (Reinold, Macrina, Fleisig, Aune, & Andrews, 2018)	II	Pitching injury rates	6-week weighted ball training program	13–18	Injury rates	↑	The program resulted in increased injury rate.
Basketball (Emery et al., 2021)	III-I	Ankle and knee injury	SHRed Injuries Basketball Neuromuscular Training	11–18	All-complaint ankle and knee injuries	↓	Protective against all-complaint ankle and knee injuries (IRR = 0.64; 95% CI: 0.51, 0.79)
Basketball (Longo et al., 2012)	II	Basketball-related injury	FIFA 11 + program	I: M age = 13.5 C: Mage = 15.2	Overall injury rates per 1000 athlete exposures	↓*	Intervention group injury rates lower than control group (0.95 vs 2.16; P = 0.0004)
					Training injury rates	↓*	Intervention group injury rates lower than control group (0.14 vs 0.76; P = 0.007)
					Lower extremity injury rates	↓*	Intervention group injury rates lower than control group (0.68 vs 1.4; P = 0.022)
					Acute injury rates	↓*	Intervention group injury rates lower than control group (0.61 vs 1.91; P < 0.001)
					Severe injury rates	↓*	Intervention group injury rates lower than control group (0 vs 0.51; P = 0.004)
Basketball (Foss et al., 2018)	III-I	Basketball-related injury	CORE (trunk and lower extremity exercises) vs SHAM (resistance band running)	5–18 years (M = 14)	Injury rate / 1000 Athlete Exposures (AE)	↓*	Basketball (rate = 4.99 injuries/1000 AE) athletes in the CORE group demonstrated lower injury incidences than basketball (rate = 7.72 injuries/1000 AE; F1,275 = 9.46, P 0.002) athletes in the SHAM group.
Basketball (McGuine et al., 2011)	II	Acute ankle injuries	Lace-up ankle brace	14–18	Injury rates	↓*	The rate of acute ankle injury (per 1000 exposures) was 0.47 in the braced group and 1.41 in the control group (Cox hazard ratio [HR] 0.32; 95% confidence interval [CI] 0.20, 0.52; P < 0.001).
Field Hockey (Barboza et al., 2019)	III-I	Non-contact / Contact: Ball or stick; Ground; Player	Warm up program	M age = 12.1	Injury rate	↓	The injury rate was lower in the intervention group (hazard ratio of 0.64 [95% CI = 0.38, 1.07])
					Time loss injury rate per 1000 player hours	↓	Burden of injuries on players' field hockey participation was lower in the intervention group (difference of 8.42 [95% CI = 4.37, 12.47] days lost per 1000 player-hours of field hockey).
Floorball (Åkerlund, Waldén, Sonesson, & Hägglund, 2020)	III-I	Acute, overuse, lower limb and knee	Injury prevention exercise program	12–17	Injury Incidence	↓	35% lower incidence of injuries in intervention group. Adjusted IRR 0.65, 95% CI 0.52 to 0.81)
					Acute injuries	↓	45% lower incidence of acute injuries (adjusted IRR 0.55, 95% CI 0.37 to 0.83) in intervention group
					Overuse injuries	-	No difference in overuse injuries prevalence (adjusted prevalence rate ratio 0.96, 95% CI 0.73 to 1.26)
Floorball (Åkerlund, Waldén, Sonesson, Lindblom, & Hägglund, 2022)	II	Acute, gradual onset, substantial, and time loss injuries	Injury prevention exercise program	12–17	Total injury incidence	-	No statistically significant differences between groups
					Weekly injury prevalence	↓	35% lower among higher dose group compared to low-dose group
					Weekly prevalence of substantial injury	↓	60% lower among higher dose group compared to low-dose group
Handball (Achenbach et al., 2018)	II	Severe knee injury	Neuromuscular exercise program	<16	Incidence per 1000 hours	↓*	Injury occurred more often in control group (OR: 011 [95% CI: 0.01–0.90]), p = 0.019
		Ankle, lower & upper extremities		<18		-	No significant differences between intervention and control groups
Ice Hockey (Cusimano et al., 2011)	III-I	Hockey-related injuries due to bodychecking	Policy change (lowering bodychecking age)	6–17	Visit to ED due to bodychecking injury	↑	The odds ratio (OR) of a visit to the ED because of a bodychecking-related injury increased after the rule change (OR 1.26, 95% [CI] 1.16–1.38)

(*continued on next page*)

Table 3 (*continued*)

Sport (reference)	Evidence level	Type of injury	Intervention	Age group (years)	Outcome/Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
Ice Hockey (Emery et al., 2022)	III-2	Hockey-related injuries	Policy change (disallowing body checking)	15–17	Rate of all injury	↓	Policy prohibiting body checking in non-elite Midget leagues was associated with a 65% lower rate of all injury (IRR = 0.35 (95% CI 0.22 to 0.55))
					Rate of injury with time loss > 7 days	↓	Policy prohibiting body checking in non-elite Midget leagues was associated with a 92% lower rate of injury with time loss > 7 days (IRR = 0.08 (95% CI 0.03 to 0.20))
Ice Hockey (Lacny et al., 2014)	III-2	Hockey-related injuries	Policy change (no body checking)	11–12	Injury incidence	↓	An estimated 1273 injuries would be avoided during just one season with the policy change.
Organised sport (Kliethermes et al., 2019)	III-I	Sport-related injury	Serial sports training risk assessment and counselling	8–17	Injury risk	↓	Controls were nearly twice as likely to be injured during the intervention period after controlling for age, sex, baseline injury and level of specialisation.
Physical activity (Collard, Verhagen, Chinapaw, Knol, & van Mechelen, 2010)	II	Physical activity injury	Injury Prevention Lessons Affecting Youth (iPlay)	10–12 (overall)	Total injury	↓	Small nonsignificant intervention effect on total (HR,0.81; 95% [CI], 0.41–1.59),
					Sports club injury	↓	Small nonsignificant intervention effect on sports club (0.69; 0.28–1.68)
					Leisure time injury	↓	Small nonsignificant intervention effect on leisure time injuries (0.75; 0.36–1.55).
				10–12 (less physically active)	Total injury	↓	Total injury incidence (HR,0.47; 95% CI, 0.21–1.06)
					Sports club injury	↓*	Sports club injury incidence was significantly reduced (HR,0.23; 95% CI, 0.07–0.75)
					Leisure time injury	↓	Leisure time injury incidence (HR, 0.43; 0.16–1.14).
Physical activity (Emery et al., 2020)	II	Sport or recreational activity-related injury	iSPRINT	11–16 (girls)	Medical attention injuries	↓	Protective for girls (IRR = 0.289, 95% CI 0.135 to 0.619)
				11–16 (boys)	Medical attention injuries	-	Not protective for boys (IRR = 0.639, 95% CI 0.266 to 1.532)
Soccer (Bollars et al., 2014)	III-3	Soccer-related injuries	Preventive program	M age = 22	Injury rate	↓	21.1% reduction in injury rate (rate ratio = 0.789; 95% confidence interval, 0.776–0.802)
Soccer (Krutsch et al., 2020)	III-2	Severe knee injuries	Specifically adapted preventive training modules	I: M age = 22.7 C: M age = 21.9	Severe knee injury incidence / 1000 h football exposure	↓*	Intervention group severe knee injury (incidence: 0.38 per 1000 h football exposure; prevalence: 9.8%) compared to control group (incidence: 0.68 per 1000 h football exposure; prevalence: 18.0%; $p < 0.05$)
Soccer (Hasebe et al., 2020)	III-I	Hamstring injury	Nordic Hamstring exercise program	C: M age = 16.3 I: M age = 16.7	Time lost to sport injury rate due to hamstring injury	↓*	Time lost to sport injury rate was 1116.3 / 10,000 competition hours for the control compared to 113.7 for the intervention (RR9.81 (CI: 5.42–17.8) $p < 0.001$))
Soccer (Gatterer, Ruedl, Faulhaber, Regele, & Burtscher, 2012)	III-3	Soccer-related injuries	FIFA 11 program	M age = 22	Injury rates / 1000 match hours	↓	Lower injury rate among 6th league intervention team (11.8 (0.3–3.3) than 6th league control team (14.0 (1.8–26.2)
					Injury rates / 1000 total hours	↓	Lower injury rate among 6th league intervention team (3.3 (0.7–5.9) than 6th league control team (4.3 (1.3–7.3)
Soccer (Chena et al., 2019)	III-I	Soccer-related injuries	Exercise program	16–23	Frequency of injury	↓	63.8% reduction in frequency of injury
					Number of injured players	↓	32.9% reduction in number of injured players
Soccer (Hägglund et al., 2013)	III-2	ACL injuries	Neuromuscular training program	12–17	ACL injury rate (high compliance)	↓	88% reduction in the anterior cruciate ligament (ACL) injury rate (RR 0.12, 95% CI 0.01 to 0.85) among high compliance tertile compared to those in the low compliance tertile.
					ACL injury rate (low compliance)	-	Rate of injury among control group players was not significantly different from those in the low-compliance tertile (RR 0.77, 95% CI 0.27 to 2.21).
Soccer (Kiani, Hellquist, Ahlqvist, Gedeborg, & Byberg, 2010)	III-I	Soccer-related knee injuries	HarmoKnee preventive program	13–19	Knee injury incidence rate	↓	The preventive program was associated with a 77% reduction in knee injury incidence (crude rate ratio, 0.23; 95% confidence interval, 0.04–0.83).
					Non-contact knee injury incidence rate	↓	The noncontact knee injury incidence rate was 90% lower in the intervention group (crude rate ratio, 0.10; 95% confidence interval, 0.00–0.70).

Table 3 (*continued*)

Sport (reference)	Evidence level	Type of injury	Intervention	Age group (years)	Outcome/Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
Soccer (Krist, van Beijsterveldt, Backx, & Ardine de Wit, 2013)	II	Soccer-related injuries	10 exercise injury prevention program	18–40 (C:M age = 25.1; I: M age = 24.4)	Injury rates	-	No significant differences in the injury rate were found between the two groups.
Soccer (Grooms, Palmer, Onate, Myer, & Grindstaff, 2013)	III-2	Lower extremity injury	F-MARC 11þ – warm up program	18–25	Lower extremity injury	↓	The intervention season had reductions in the relative risk (RR) of lower extremity injury of 72% (RR = 0.28, 95% confidence interval = 0.09, 0.85).
					Time lost due to lower extremity injury	↓*	The intervention season had reductions in the time lost to lower extremity injury (P = 0.01).
Soccer (Owoeye et al., 2014)	II	Soccer-related injury	FIFA 11+	14–19	Overall rate of injury	↓*	The FIFA 11 + programme significantly reduced the overall rate of injury in the INT group by 41% [RR = 0.59 (95% CI: 0.40 – 0.86; p = 0.006)]
					All lower extremity injuries	↓*	The FIFA 11 + programme significantly reduced all lower extremity injuries by 48% [RR = 0.52 (95% CI: 0.34 – 0.82; p = 0.004)].
Soccer (Silvers-Granelli, Bizzini, Arundale, Mandelbaum, & Snyder-Mackler, 2018)	II	Soccer-related injury	FIFA 11+	18–25	Injury rates for high compliance group compared to low compliance	↓*	The Low Compliance group [mean (M) = 13.25, 95% confidence interval (CI) 9.82–16.68, injury rate (IR) = 10.35 ± 2.21] had a significantly higher injury rate than the High Compliance group (M = 8.33, 95% CI 6.05–10.62, IR = 10.35 ± 2.21), p = 0.02.
Soccer (Slauterbeck et al., 2019)	II	Lower extremity injury	FIFA 11+	14–18	Lower extremity injury rates	↑	There were 196 lower extremity injuries among 1825 athletes in the FIFA 11 + group and 172 injuries among 1786 athletes in the control group (1.59 and 1.47 injuries per 1000 Aes, respectively; P = 0.771).
Soccer (Steffen et al., 2013)	II	Soccer-related injury	FIFA 11+	13–18	High adherence	↓	Injury risk was lower for players who highly adhered to the 11+ (injury rate ratio, IRR = 0.28, 95% CI 0.10 to 0.79).
Soccer (Waldén, Atroshi, Magnusson, Wagner, & Hägglund, 2012)	II	Acute knee injuries	Neuromuscular training	12–17	Anterior cruciate ligament injury rate	↓	A 64% reduction in the rate of anterior cruciate ligament injury was seen in the intervention group (rate ratio 0.36, 95% confidence interval 0.15 to 0.85).
					Severe knee injury rate	-	No significant rate reductions were seen for secondary outcomes.
					Acute knee injury	-	No significant rate reductions were seen for secondary outcomes.
Soccer (Whalan et al., 2019)	III-I	Football-related injuries	FIFA 11+ (comparing standard 11 + to rescheduled part 2 of FIFA 11 +)	Standard: M age = 24.8 Rescheduled M age = 23.8	Days lost due to injury	↓*	Significantly lower days lost to injury among rescheduled group (5815vs4303) p = 0.026
					>28 days lost (severe injury)	↓*	Significantly lower days lost to severe injury among rescheduled group (59vs33) p = 0.012
Soccer (Zarei et al., 2020)	II	Football-related injuries	FIFA 11 + Kids	7–14	Injury burden	↓	Injury burden (lay-off days per 1000 h) was 58% lower in the intervention group compared to the control group (RR 0.42 95%-CI 0.37, 0.48)
					Lower extremity injury	↓	Lower extremity injuries (55% reduction) were reduced in the intervention group compared to the control group.
					Training injury	↓	Training (45% reduction) were reduced in the intervention group compared to the control group.
					Knee injuries	↓	Knee injuries (66% reduction) were reduced in the intervention group compared to the control group.
Soccer (Indoor) (Bello et al., 2011)	III-I	Muscle and ankle joint injuries	Rhythmic stabilisation (RS)technique	18–27	Number of muscle and joint injuries	↓	Lower number of injuries among RS group however non-significant (F = 0.192, p value = 0.096).
Soccer (Indoor) (Marshall, Lopatina, Lacny, & Emery, 2016)	II	Soccer-related injuries	Neuromuscular training	13–18	Total number of injuries	↓	38% reduction in injury risk (rate difference = – 1.27/1000 player hours (95% CI – 0.33 to – 2.2)) compared to a standard warm up.
Sports Injury (Richmond, Kang, Doyle-Baker, Nettel-Aguirre, & Emery, 2016)	II	Sports-related injury risk	Neuromuscular training	11–15	All sports injury	↓	reduced risk of all injury: incidence rate ratio (IRR)all injury = 0.30 (95% CI, 0.19–0.49)
					Lower extremity injury	↓	IRR lower extremity injury = 0.31 (95% CI, 0.19–0.51)
					Ankle sprain injury	↓	IRR ankle sprain injury = 0.27 (95% CI, 0.15–0.50)
					Knee sprain injury	↓	IRR knee sprain injury = 0.36 (95% CI, 0.13–0.98)

(*continued on next page*)

Table 3 (*continued*)

Sport (reference)	Evidence level	Type of injury	Intervention	Age group (years)	Outcome/Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
Track and Field (Mendez-Rebolledo et al., 2021)	II	Sports-related lower limb injury	Neuromuscular training	11–18	Injury incidence rate	↓	The injury incidence rate was 17.89 (95% confidence interval [CI], 10.24 to 25.54) injuries per 1000 hours of athlete-exposure after CONV training. In contrast, the injury incidence rate was 6.58 (95% CI, 2.02 to 11.15) injuries per 1000 hours of athlete-exposure after NM training.
Volleyball (Foss et al., 2018)	III-I	Volleyball-related injuries	CORE (trunk and lower extremity exercises) vs SHAM (resistance band running)	5–18 years (M = 14)	Injury rate / 1000 Aes	↓*	Volleyball (rate = 5.74 injuries/1000 Aes) athletes in the CORE group demonstrated lower injury incidences than volleyball (rate = 11.63 injuries/ 1000 Aes; F1,149 = 11.36, P = 0.001,) athletes in the SHAM group.

Abbreviations: CI: Confidence Interval; ED = Emergency Department; HR = Hazard Ratio; IRR = Incidence Rate Ratio; M = Mean; OR = Odds Ratio; RR = Relative Risk; RS = Rhythmic Stabilisation; *=statistically significant ($p < 0.05$). ↓ = reduced injury; ↑=increased injury;- = no change; I = Intervention; C = Control.

(Achenbach et al., 2018), track and field (Mendez-Rebolledo et al., 2021), and volleyball (Foss, Thomas, Khoury, Myer, & Hewett, 2018) (Table 3).

Rule changes were commonly related to either increasing or reducing injury risk as a result of body checking in youth ice hockey. An analytical cross-sectional study (evidence level III-I) found increased odds (OR 1.26; 95% confidence interval [CI] 1.16–1.38) of an emergency department visit due to a body checking injury among younger adolescents when the age for allowing the practice was lowered (Cusimano et al., 2011).

Conversely, an RCT (evidence level III-2) found disallowing body checking in youth leagues was estimated to reduce injury risk for 11–12-year-olds (an estimated 1,273 injuries would be avoided during just one season with the policy change) (Lacny et al., 2014). Additionally, a cohort study (evidence level III-2) found disallowing body checking resulted in a lower rate of all injury (65% lower rate of all injury (Incident rate ratio [IRR] = 0.35 [95% CI 0.22 to 0.55]) and rate of injury with time loss > 7 days (92% lower rate (IRR = 0.08 [95% CI 0.03 to 0.20]) for 15–17-year-olds (Emery et al., 2022) (Table 3).

With respect to equipment and sports injury risk, a cohort study (evidence level III-3) identified shoulder stabilizing brace wear resulted in significantly reduced lower posterior labral tear injury rates (relative risk [RR] = 0.46; 95% CI 0.16–1.30; p = 0.14) and in less practice or game time missed for those using a brace (8.7 vs 36.60 games and practices missed due to shoulder injury; p = 0.002) among 18–22 year old American football players (Baker, Tjong, Dunne, Lindley, & Terry, 2016). An RCT (evidence level II) found lace-up ankle braces significantly reduced the rate of acute ankle injury in basketball for 14–18 year-olds, with a rate of 0.47 in the braced group compared with 1.41 in the control group (Cox hazard ratio [HR] 0.32; 95% CI 0.20–0.52; $p < 0.001$) (McGuine, Brooks, & Hetzel, 2011) (Table 3).

3.3. Road traffic injury

Of the 21 studies (33.9% of all included studies) reporting interventions to reduce road traffic injury among adolescents, all were from high income countries. Sixteen studies (76.2%) were aimed at preventing driver-related motor vehicle crashes. Among these, legislative approaches were the most common injury prevention intervention, documented in 16 (76.2%) studies. Graduated driver licensing (GDL) schemes were the most common legislative approaches, reported in eight of the studies examining motor-vehicle crashes in Australia (Hirschberg & Lye, 2020), the US (Bonne et al., 2018; Conner and Smith, 2017; Fell et al., 2011; Kaafarani et al., 2015; Males, 2013; Rouse et al., 2013) and Israel (Toledo, Lotan, Taubman-Ben-Ari, & Grimberg, 2012).

Evidence indicates GDL schemes appear to be effective in preventing motor-vehicle-related injuries and fatalities for adolescents. A cohort study (evidence level III-2) found rates of fatal motor-vehicle crashes were significantly lower for 16–17 year-olds (from 14.0 to 8.6 per 100,000 people, p = 0.006) and 18–20 year-olds (from 21.2 to 13.7 per 100,000 people, $p < 0.001$) after the adoption of GDL schemes 54. A cohort study (evidence level III-2) found injury crash rates of GDL participants are lower compared to non-participants by 12.7% ($p < 0.05$) (Toledo et al., 2012). Another study (quasi experimental study; evidence level III-2) found a 59% reduction ($p < 0.001$) in rates of fatal crashes in 14–18 year-olds after the introduction of GDL, with the effect greatest among 16 year-old drivers (−22%; $p < 0.001$) (Rouse et al., 2013). Significantly lower motor-vehicle crash related injury rates were seen among 16–20 year-old occupants (16–17 year-olds: RR = 0.94; 95% CI 0.88–0.99; 18–20 year-olds: RR = 0.75; 95% CI 0.64–0.88) after the introduction of GDL schemes, however the evidence level of this analytical cross-sectional study was lower (IV) (Conner & Smith, 2017).

Conversely, a cohort study (evidence level III-2) identified that California's GDL scheme resulted in a 7% net increase in traffic fatalities (approximately 60 more fatal crashes and fatalities per year) for 16–25 year-olds compared to the control group not exposed to GDL (Males, 2013) (Table 4).

A range of legislative approaches were found to be ineffective at preventing injury. An analytical cross-sectional study (evidence level IV) reporting the impact of text-messaging restrictions in the US (Michigan) did not identify significant changes in fatal and disabling injury crash rates for 16, 17, and 18 year-olds, nor non-disabling injury crash rates for 18 and 19 year-olds (Ehsani, Bingham, Ionides, & Childers, 2014). In fact, the study found the introduction of legislation increased fatal and disabling injury crash rates for 19 year-olds and 20–24 year-olds, as well as non-disabling injury crash rates for 16, 17, and 20–24 year-olds (Ehsani et al., 2014).

Similarly, a Canadian analytical cross-sectional study (evidence level IV) (Richmond et al., 2016) reported a 408% increase in motor-vehicle collision-related mortality rates for 15–19-year-olds between 1950 and 1970, despite the implementation of legislation criminalizing drinking and driving and requiring seat belts in all new vehicles. However, significant reductions were seen in the next decade with the introduction of additional legislation targeting mandatory seat belt laws and tougher penalties for impaired drivers (Table 4).

The value of combining legislation change with education was underscored by a quasi-experimental study (evidence level II-3) from New Jersey in the United States (Bonne, Suber, Anderson, & Livingston, 2018), which found no initial impact on teenage driver death upon introduction of GDL; however when the GDL scheme was combined with comprehensive education, a significant reduction in adolescent driver deaths (42 vs 22, $p < 0.05$) and adolescent passenger deaths in vehicles operated by another adolescent (19 vs 11 $p < 0.05$) were found. Education-based interventions were also evaluated and found to be effective in significantly reducing the incidence of nonfatal bicycle injuries for 12–13 year-olds (intervention group [$\chi^2 = 8.137$, $p = 0.004$] (Ji, Ye, Lu, Li, & Gao, 2017), annual incidence of moped and scooter injuries (0.8% in 2011 to 0.3% in 2013 [$p < 0.001$]), and estimated incidence of injuries per new moped/scooter license (from 1.8% in 2011 to 1.0% in 2013 [$p = 0.001$]) for 15–16 year-olds (Kosola, Salminen, & Kallio, 2016) and the number of motor-vehicle crash-related injuries treated at a level 1 trauma center for 16–21 year-olds (-37% [$p < 0.05$]) (Layba, Griffin, Jupiter, Mathers, & Mileski, 2017) (Table 4).

3.4. Other unintentional injuries

Seven studies reported the impact of interventions to prevent non-sport and non-road traffic injuries for adolescents. An RCT (evidence level II) found school-based education programs to be effective in reducing the fall injury rates for 7–12-year-olds in the Netherlands (injury incidence density [IID] of 0.14 fall-related injuries per 1,000 hours of physical activity [95% CI 0.09 to 0.18], compared to 0.26 [95% CI: 0.21 to 0.32] for control) (Nauta et al., 2013). While another RCT (evidence level II) found home modifications reduced the rate of falls requiring medical treatment among 10–19-year-olds in New Zealand (0.007 mean annual injury rate [intervention] and 0.028 [control]) (Keall et al., 2015).

An analytical cross-sectional study (evidence level IV) exploring raising minimum alcohol prices in Canada found this approach had no effect on emergency department visits due to an alcohol-related fall injury (Sherk, Stockwell, & Callaghan, 2018). A cohort study (evidence level III-2) on community coalition training in Australia that aimed to increase evidence-based practices that reduce youth injury risk factors (Berecki-Gisolf, Rowland, Reavley, Minuzzo, & Toumbourou, 2001–2017. 2020) was found to result in significant reductions in unintentional and transport injury, as well as unintentional injury-related hospital admissions for 10–14 and 15–19-year-olds when compared to 20–24-year-olds (Table 5).

In the United States, a case series (evidence level IV) found relaxing of legislation around age restrictions for purchasing fireworks was found to have higher burn injury for < 21-year-olds (Myers & Lehna, 2017). Also in the United States, a cohort study (evidence level III-3) found states with more lenient gun control laws had greater firearm-related hospital admissions and in-hospital mortality for < 20-year-olds (Tashiro, Lane, Blass, Perez, & Sola, 2016). Limited change was seen in burn injuries for adolescents aged 10–14-years in an analytical cross-sectional study (evidence level IV) in Canada after the implementation of legislation regarding flammability requirements for children's sleepwear and bedding, and regulations and labeling requirements for child resistant lighters (Richmond et al., 2016) (Table 5).

4. Discussion

Over the past 30 years, the proportion of global deaths and DALYs in adolescents due to injury has barely changed, which arguably reflects failure to sufficiently invest in interventions to reduce injury risk (Peden et al., 2022). To build an investment case for the prevention of adolescent injury-related harm, it is vital to examine the evidence around interventions aimed at preventing injury for this at-risk age group. Cost-effectiveness will be maximized when investment is made in those interventions that are known to be effective. Therefore, this study systematically reviewed the literature reporting interventions for the prevention of unintentional and road transport-related injury among adolescents to identify the evidence for effective injury prevention efforts. This review found studies were overwhelmingly from high-income countries, a high proportion of interventions targeted sports injury prevention, and there was low consideration of equity.

The predominance of studies evaluating injury prevention interventions for adolescents in high-income countries does not reflect the global injury burden. The Global Burden of Disease (GBD) Study indicates significantly higher deaths and DALYs due to road transport and other unintentional injury among adolescents in low-income countries, with the burden declining as income levels rise (Peden et al., 2022). Consistent with the socioeconomic gradient in injury risk (Yuma-Guerrero et al., 2018; Goldman et al., 2018), it was disappointing how few studies adequately considered the contribution of equity when evaluating interventions, even in relation to gender, which was only reported in two thirds of studies. Similarly, no studies evaluated injury prevention interventions for First Nations adolescents, despite known elevated rates of injury among these populations (Azzopardi et al., 2018). It is recommended that researchers, practitioners, and donors prioritize the development, implementation, and high-quality evaluation of interventions aiming to prevent or reduce transport and other unintentional injury among neglected adolescent populations such as First Nations adolescents, adolescents residing in low and middle income countries with LMICs, adolescents residing in regional and remote areas, adolescents with a disability, and adolescents of a culturally and linguistically diverse or low socio-economic background among others. Addressing such knowledge gaps about which interventions work to reduce injury among these populations at increased risk of injury-related harms will save lives.

At the same time, there may be economies of scale in implementing interventions known to be effective at reducing adoles-

Table 4
Injury prevention interventions for adolescent road traffic injury, grouped by effectiveness (n = 21).

Vehicle type (reference)	Evidence level	Outcome/ Severity	Intervention name	Age group (years)	Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
Bicycle (Ji et al., 2017)	III-I	Nonfatal	Road safety education	12–13	Incidence of bicycle injuries	↓*	In the intervention group, the incidence decreased significantly after the intervention (χ 2 = 8.137, p = 0.004), while no significant change was observed in the control group
Bicycle and Pedestrian (Inada et al., 2019)	III-I	Fatal; Nonfatal	Area-Wide Traffic-Calming Zone 30 Policy	15–24	Occurrence of fatal and serious injury	↓	Cumulative relative changes of and −0.19 (95% CI = −0.28, −0.090) in the rate ratio between September 2011 and December 2016.
Mopeds & scooters (Kosola et al., 2016)	III-2	Nonfatal	Driver education	15–16	Annual incidence	↓*	After the law change in 2011, the annual incidence of moped/scooter injuries among 15-year-olds in our area decreased from 0.8% in 2011 to 0.3% in 2013 (p < 0.001)
					Estimated incidence of injuries per new moped/scooter license	↓*	Estimated incidence of injuries per new moped/ scooter license declined from 1.8% in 2011 to 1.0% in 2013 (p = 0.001)
Motorcycle (Hassan et al., 2017)	III-2	Nonfatal	Motorcycle helmet legislation	<21 M age= 18.4	Motorcycle crash related traumatic Brain Injury-	↓*	Universal helmet legislations lowered the rate of MCC-related TBI injures by a factor of 2.15 (b coefficient: 2.15; 95% confidence interval: 0.91–10.18; P = 0.04).
Motor vehicle (Anderson, Carlson, & Rees, 2017)	IV	Nonfatal	Booster Seats	10–12	Any injury	↓	In children aged 10–12 years, the use of a booster seat was associated with a 33% reduction in the odds of any injury relative to being restrained by a seat belt alone (OR = 0.675, 95% CI = 0.505, 0.902).
Motor vehicle (Bonne et al., 2018)	III-3	Fatal	Graduated Driver Licensing (GDL)	16–20	Teen driver deaths (initiation of GDL)	-	No change in number of dead teen drivers (44 vs 49, p > 0.05)
					Teen driver deaths (GDL + comprehensive campaign)	↓*	After the comprehensive campaign, decreases are seen in dead teenaged drivers (42 vs 22, p < 0.05)
					Teenage passenger deaths in vehicles operated by another teen (GDL + comprehensive campaign)	↓*	Decreases in the number of dead teenaged passengers in a vehicle operated by another teen (19 vs 11p < 0.05).
Motor vehicle (Conner & Smith, 2017)	IV	Nonfatal	GDL	16–20	Motor vehicle crash related injury rates (16–17 years)	↓*	The post-GDL period was statistically associated with lower injury rates for occupants ages 16–17 years combined (RR = 0.94; 95% CI, 0.88–0.99).
					Motor vehicle crash related injury rates (18–20 years)	↓*	In addition, injury rates for occupants ages 18–20 years combined (RR = 0.75; 95% CI, 0.64–0.88) were statistically lower for the post-GDL period.
Motor vehicle (Fell, Jones, Romano, & Voas, 2011)	III-2	Fatal	GDL	16–17	Fatal crash involvements	↓*	The adoption of a GDL law of average strength was associated with a significant decrease in fatal crash involvements of 16- and 17-year-old drivers relative to fatal crash involvements of one of the 2 comparison groups (19–20 & 20–25).
Motor vehicle (Hirschberg & Lye, 2020)	III-I	Nonfatal	Signalling of the GDL system changes	18–25	Injuries requiring hospitalisation	↓	Resulted in around 6 less injuries requiring hospitalisation per month for females and around 7 less injuries requiring hospitalisation for males per month.
		Fatal			Fatalities	↓	For fatalities, these signals only had an impact for males of around 0.6 fewer fatalities per month.
		Nonfatal	Demerit points for traffic violations		Injuries requiring	↓	Demerit point system introduced for traffic violations

Table 4 (*continued*)

Vehicle type (reference)	Evidence level	Outcome/ Severity	Intervention name	Age group (years)	Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
					hospitalisation		in December 2002 only had a short-term impact of reducing injuries requiring hospitalisation of around 2 per month for males.
		Nonfatal	Extra year on "P plates" for those under 21 at time of licensing and to remain alcohol free while driving for the entire probationary period with peer passenger restrictions introduced for first year P platers		Injuries requiring hospitalisation	↓	approximately 5 fewer injuries for males and around 4 less injuries for females.
		Fatal			Fatalities	↓	around 0.8 less fatalities per month for males.
		Nonfatal	Stricter mobile phone restrictions for P platers		Injuries requiring hospitalisation	-	No impact on injuries requiring hospitalisation for either males or females.
		Fatal			Fatalities	↓	Around 1 less fatality per month for males and around half that effect for females
		Nonfatal	Minor modifications to the requirement of carrying a licence and the introduction of alcohol interlock measures for probationary drivers under the age of 26 found to be guilty of a Blood Alcohol Concentration over the limit.		Injuries requiring hospitalisation	↑*	For males we found a significant increase of around 4 injuries requiring hospitalisation per month
Motor vehicle (Kaafarani et al., 2015)	III-2	Fatal	GDL	16–17	Fatal motor vehicle crashes (fMVC)	↓*	The rates of fMVC decreased in the age group of 16 years to 17 years (from 14.0 to 8.6 per 100,000 people, p = 0.006),
				18–20		↓*	The rates of fMVC decreased in the age group of 18 years to 20 years (from 21.2 to 13.7 per 100,000 people, p < 0.001)
Motor vehicles (Males, 2013)	III-2	Fatal	GDL	16–25	Motor vehicle fatalities among car occupants	↑*	The 16–25 age group subjected to GDL suffered significant net increases of 7% in traffic fatalities compared to the control group not exposed to GDL. For the 16–25 age group as a whole, California's GDL was associated with approximately 60 more fatal crashes and fatalities per year.
Motor vehicles (Rouse et al., 2013)	III-2	Fatal	GDL	14–18	Fatal crashes	↓*	Rates of fatal crashes for 14- to 18-year-olds were reduced 59%. The largest decrease was found among 16-year-old drivers who evidenced a reduction in crashes of 22% (p < 0.001), followed by 17-yearolds at 13% (p < 0.001) and 18-year-olds at 8% (p < 0.001).
Motor vehicles (Toledo et al., 2012)	III-2	Nonfatal	GDL	17–24	Injury crash involvement	↓*	The crash rates of GDL participants are lower compared to non-participants by 12.7% (p < 0.05)
Motor vehicle (Ehsani et al., 2014)	IV	Fatal and disabling injury	Text messaging restrictions	16–24	Fatal and disabling injury change in crash rate (16 years)	-	No significant change.
					Fatal and disabling injury change in crash rate (17 years)	-	No significant change.
					Fatal and disabling injury change in crash rate (18 years)	-	No significant change.
					Fatal and disabling injury change in crash rate (19 years)	↑	Fatal and disabling injury crash rates increased by 0.43 crashes per 10,000 drivers.
					Fatal and disabling injury change in crash rate (20–24 years)	↑	Fatal and disabling injury increased by 0.32 crashes per 10,000 drivers
		Nonfatal and non-disabling injury			Non-disabling injury change in crash rate (16 years)	↑	Increased by 0.09 crashes per 10,000 licensed drivers

(*continued on next page*)

Table 4 (*continued*)

Vehicle type (reference)	Evidence level	Outcome/ Severity	Intervention name	Age group (years)	Measures of effect	Direction of effect (↓↑-) *= statistical significance	Summary of impact
					Non-disabling injury change in crash rate (17 years)	↑	After the introduction of the restriction, nondisabling crash rates increased by 0.75 crashes per 10,000 licensed drivers a
					Non-disabling injury change in crash rate (18 years)	-	No significant change.
					Non-disabling injury change in crash rate (19 years)	-	No significant change.
					Non-disabling injury change in crash rate (20–24 years)	↑	Nondisabling injury crash rates increased by 0.33 crashes per 10,000 drivers, respectively
Motor vehicle (Ferdinand et al., 2015)	III-2	Nonfatal	Text messaging bans	15–21	Motor vehicle injury-related hospitalisations	↓	Texting bans were marginally associated with MVC-related hospitalisations among those aged 15 to 21 years in sampled hospitals (IRR = 0.92; 95% CI = 0.84, 1.00; P = 0.081)
Motor vehicle (Fell, Scherer, Thomas, & Voas, 2014)	III-2	Fatal	Social host prohibitions (SHP)	<21	Underage drinking driver fatal crashes	↓	SHP laws were found to have a negative but nonsignificant impact on Fatality Analysis Reporting System ratios for drivers younger than aged 21
			Fake identification laws (FID)			↓*	For those drivers younger than aged 21 years, FID supplier laws were associated with significant decreases in Fatality Analysis Reporting System ratios after states adopted these laws (−1.0%, P = 0.030).
Motor vehicle (Scherer, Fell, Thomas, & Voas, 2015)	III-2	Fatal	Dram Shop, Responsible Beverage Service Training, and State Alcohol Control Laws	<21	The ratio of drinking to nondrinking drivers under age 21 involved in fatal crashes	↓*	Dram shop liability laws were associated with a 2.4% total effect decrease (direct effects: β = 0.019, p = 0.018). Similarly, RBS training laws were associated with a 3.6% total effect decrease (direct effect: β = 0.048, p = 0.001) in the ratio of drinking to nondrinking drivers under age 21 involved in fatal crashes.
Motor vehicle (Sherk et al., 2018)	IV	Nonfatal	Raised alcohol minimum prices	13–25	Emergency department presentations due to alcohol-related motor vehicle collisions	↓	Rates of ED visits among males aged 13–25 for MVCs decreased substantially during this study.
Motor vehicle (Richmond et al., 2016)	IV	Fatal	Criminal Law Amendment Act (Introduced Drinking & Driving Offences) (1969); Motor Vehicle Safety Act – Seat Belts Required in All New Vehicles (1971); Mandatory Seat Belt Laws in Ontario, Quebec, Saskatchewan and British Columbia (1976–1977); Amendments to Criminal Code – Tougher Penalties for Impaired Drivers (1985); National Occupant Restraint Program – Campaign to Increase Seatbelt Usage (1989); Graduated Licensing Programs Introduced in Most Canadian Jurisdictions (1994)	15–19	Change in injury mortality rates before and after specific interventions	↑	For 15–19-year-olds, there was a 408% increase in motor vehicle collision-related mortality rates between 1950 and 1971; however, a significant change in slope was noted during the period 1978–1985, compared to 1972–1977 (Est. = −0.10, 95% CI = −0.20, −0.007) across all age groups.
Motor vehicle (Layba et al., 2017)	III-I	Nonfatal	The Save A Life Tour (SALT) – safe driving awareness program	16–21	Nonfatal hospitalised injuries	↓*	A risk reduction of 37% (p < 0.05) in the number of adolescent motor vehicle crash-related injuries treated at a level 1 trauma centre
Road traffic injuries (Edwards et al., 2013)	III-3	Nonfatal	Free Bus Travel	12–16	Road casualty rates	↓	Road casualty rates declined, but the pre–post ratio of change was greater in young people than adults (ratio of ratios 0.84; 95% CI 0.82 to 0.87).

Abbreviations: ED = Emergency Department; GDL = Graduated Driver Licensing; ↓= reduced injury; ↑=increased injury;-= no change.

Table 5
Injury prevention interventions for other adolescent injury types (n = 7).

Injury type	Severity	Intervention	Evidence level	Country	Age group (years)	Outcome/Measures of effect	Direction of effect (↓↑-)	Summary of impact
Burns	Nonfatal	Firework laws (Myers & Lehna, 2017)	IV	US	<21	Injury rate / 100,000	↑* (	19.6% increase in injury rate /100,000 (p = 0.019)
						Inpatient admissions	↑*	Increased proportion of injuries requiring inpatient admission (28.9% in 2006 to 50.0% in 2012, P < 0.001)
						Mean length of hospital stay	↑*	Longer mean length of hospital stay (3.12 days in 2006 to 7.35 days in 2012, P < 0.001).
Burns	Fatal	Hazardous Products Act – Children's sleepwear & bedding flammability requirements; Child resistant lighters regulation & labelling requirements (Richmond et al., 2016)	IV	Canada	10–14	Change in slope in injury mortality rates before and after specific interventions	-	+0.02 change in slope (95% CI: 0.003–0.03)
Falls	Nonfatal	Raised alcohol minimum prices (Sherk et al., 2018)	IV	Canada	13–25	Emergency department visits alcohol-related falls	-	No change.
	Nonfatal	School based education program (Nauta et al., 2013)	II	The Netherlands	7–12 (M = 10.7)	Injury rate	↓	Injury incidence density (IID) of 0.14 fall-related injuries per 1000 h of physical activity (95% CI 0.09 to 0.18) for intervention, compared to 0.26 (95% CI: 0.21 to 0.32) for control.
	Nonfatal	Home Injury Prevention Intervention (HIPI) (Keall et al., 2015)	II	New Zealand	10–19	Falls requiring medical treatment	↓	0.007 mean annual injury rate (intervention) and 0.028 (control).
Firearm injury*	Nonfatal	Gun control laws comparing lenient vs strict states (Tashiro et al., 2016)	III-3	US	<20	Hospital admission for firearm injury	↑* (lenient states)	Lenient states had a proportionally higher rate of accidental injury (31%) versus strict states (17%), p < 0.001.
	Fatal					In-hospital mortality	↑* (lenient states)	On 1:1 propensity score–matched analysis, in-hospital mortality by case was higher in lenient (7.5%) versus strict (6.5%) states, p = 0.013.
All injury (unintentional + transport)	Nonfatal	Community coalition training (Berecki-Gisolf et al., 2001–2017. 2020)	III-2	Australia	10–14	Municipal rates of hospital admission for all injury	↓*	Compared to phase 0 – implementation (20–34yrsref) RR 1.05 (95% CI: 0.98–1.12), lower risk of injury at second cycle (phase 6) RR:0.92 (0.86–1.00) (p < 0.05)
					15–19		↓*	Compared to phase 0 – implementation (20–34yrsref) RR 1.01 (95% CI: 0.95–1.08), lower risk of injury at second cycle (phase 6) RR:0.90 (0.84–0.98) (p < 0.05)
Unintentional injuries					10–14	Municipal rates of hospital admission unintentional injury	↓*	Compared to phase 0 – implementation (20–34yrsref) RR 0.97 (95% CI: 0.90–1.04), lower risk of injury at second cycle (phase 6) RR:0.90 (0.83–0.97) (p < 0.05)
					15–19		↓*	Compared to phase 0 – implementation (The World Bank, 2022; Australian Government National Health and Medical Research Council (NHMRC), 2005; Aromataris, 2020; Achenbach et al., 2018; Åkerlund et al., 2020; Åkerlund et al., 2022; Anderson et al., 2017; Baker et al., 2016; Barboza et al., 2019; Bello et al., 2011; Berecki-Gisolf et al., 2001–2017. 2020,; Bollars et al., 2014; Bonne et al., 2018; Chena et al., 2019; Collard et al., 2010) RR 0.98 (95% CI: 0.91–1.05), lower risk of injury at second cycle (phase 6) RR:0.91 (0.83–0.99) (p < 0.05)

Abbreviations: AOR = Adjusted Odds Ratio; OR = Odds Ratio; RR = relative risk. Note: * reports intentional and unintentional injury, findings relevant to unintentional injury only extracted. Abbreviations: C = Control; T = Treatment US = United States of America. ↓= reduced injury; ↑ = increased injury; - = no change.

cent injury-related harms in HIC contexts, to LMICs. However, it will be vital to ensure appropriate adaptation to suit differences between settings, including available resources and cultural considerations (Stevenson et al., 2008). Alternatively, researchers should consider the development of interventions that are relevant to both HICs and LMICs simultaneously through partnership (Baker et al., 2022).

The largest body of evidence on the evaluation of adolescent injury prevention interventions was for sports injury where high quality evidence, commonly in the form of RCTs is available, albeit with the majority from high-income contexts. Soccer (football) was the sport most commonly addressed, with the vast majority of interventions comprising neuromuscular training, such as the FIFA 11 program. Evidence indicates investment in neuromuscular training, combined with strategies to encourage high adherence, will be effective in reducing injuries (such as those to the lower extremities) for a range of sports in addition to football including basketball (Emery et al., 2021; Foss et al., 2018; Longo et al., 2012), field hockey (Barboza et al., 2019), handball (Achenbach et al., 2018), track and field (Mendez-Rebolledo et al., 2021) and volleyball (Foss et al., 2018). Evidence also supports policy changes to reduce injury risk, in particular disallowing body checking in ice hockey for younger adolescents (ages 11–17 years) (Emery et al., 2022; Lacny et al., 2014). The evidence also indicates equipment such as shoulder braces and lace-up ankle braces can reduce sports injury risk among adolescents (Baker et al., 2016; McGuine et al., 2011). However, evidence gaps remain, including many popular sports not evident in this review (such as running and swimming (Hulteen et al., 2017), for adolescent girls and gender diverse youth. In addition, it is recommended that further high-quality research be conducted to identify effective interventions to prevent sports injuries in adolescents in low and middle income countries with LMICs settings and among First Nations adolescents.

Participation in sports brings a range of public health benefits (Malm et al., 2019; Guddal et al., 2019), and while sports injury generally poses low threat to life, it can significantly burden the health system (Emery & Pasanen, 2019). While evaluation of sports injury prevention interventions is valuable, better understanding of effective injury prevention is needed for high threat to life injury mechanisms, such as road traffic injury and drowning. The latter is the leading cause of unintentional injury-related mortality, and the third leading cause of DALYs globally for adolescents 10–24 years of age (Peden et al., 2022). Disappointingly this review yielded no evaluated interventions. A lack of research into effective drowning prevention interventions is indicative of the lack of investment in adolescent health more broadly, with evaluation of interventions - and subsequent investment in those interventions - lagging behind that of younger children (Peden et al., 2021; Li et al., 2018).

Similarly, despite being the leading cause of death and disability for adolescents, evaluation of road transport injury interventions was only reported in 21 studies. Strikingly, no studies evaluated interventions in low and middle income countries with LMICs. Many of the reported interventions targeted motor vehicle-related injury and used a legislative approach. Included studies indicated effectiveness of GDL schemes in reducing fatal and nonfatal motor vehicle-related injury Australia (Hirschberg & Lye, 2020), various U.S. states (Bonne et al., 2018; Conner and Smith, 2017; Fell et al., 2011; Kaafarani et al., 2015; Males, 2013; Rouse et al., 2013), and Israel (Toledo et al., 2012). As such, there is a reasonable body of evidence that indicates that GDL schemes are a recommended intervention to reduce fatal and nonfatal road transport-related injuries for adolescents. It is also apparent that the greatest effects come when integrating GDL schemes with other measures, such as comprehensive driver education (Bonne et al., 2018).

Despite the effectiveness of legislated approaches to reduce adolescent road transport injury, this review identified some unintended consequences of changes in legislation leading to increased injury risk. For example, relaxing age restrictions for purchasing fireworks led to an increase in burn injury among younger adolescents (Myers & Lehna, 2017), and higher firearm-related hospital admissions in U.S. states with more lenient gun control laws (Tashiro et al., 2016). Similar all-age experiences have been seen in the repeal of mandatory helmet wearing legislation, leading to an increase in traumatic brain injuries (Saunders et al., 2018), and lowering wages and benefits in the construction industry was associated with increased construction injury rates (Li, Zorigtbaatar, Pleités, Fenn, & Philips, 2019). These likely unintended consequences suggest that changes in legislation should be carefully considered before any policy change is undertaken. This includes a careful assessment of uneven or inequitable impacts such as the impact of firearm injuries on younger adolescents and the increased risk of occupational injury among poorer workers.

Although few studies reported the effectiveness of interventions to prevent other unintentional injury among adolescents, there are several high-quality studies that provide support for investment in interventions found to be effective. RCTs indicate significant reductions in fall injuries for 7–12 year-olds via a school-based education program in the Netherlands (Nauta et al., 2013), and fall injuries requiring medical treatment among 10–19 year-old New Zealanders after home modifications (Keall et al., 2015). Again, further well-designed studies are needed to identify effective interventions to address other unintentional injury mechanisms, as well as for wider populations such as First Nations adolescents and adolescents in low- and middle-income countries.

The authors encourage donors and governments to both support research to fill knowledge gaps, as well as use the available evidence to build an investment case for adolescent injury prevention. Evidence already exists as to the economic benefits of investing in a range of adolescent health and wellbeing initiatives (Sheehan et al., 2017), including road traffic injury prevention (Symons, Howard, Sweeny, Kumnick, & Sheehan, 2019). However, more work is needed to build the investment case around the economic benefits of preventing other unintentional injury among adolescents, and to do that, evidence of effective interventions is required.

In the absence of, or in addition to available evidence, the authors also encourage donors to consider in these investment cases, the broader economic gains associated with social, health, and environmental benefits of injury prevention interventions. These include environmental and physical health benefits associated with public and active transport (Filigrana-Villegas, Levy, Gauthier, Batterman, & Adar, 2019), the physical and mental health benefits of safe participation in sport (Finch & Owen, 2001), and the dual benefit of drowning risk reduction and opportunity for low impact physical activity that comes from learning to swim (Langendorfer, 2011), as well as their valuable role in helping countries to achieve a range of Sustainable Development Goals (Ma et al., 2020).

Preventing injury among adolescents can be challenging, which may in part explain why injury prevention efforts have traditionally focused on younger children and adults (Rivara, 2012; Patton et al., 2012). Adolescence is characterized by rapid physical, mental, social, and emotional change (Patton et al., 2016). This results in a developmental transition point for injury risk, with increasing independence seeing a shift from parental to peer supervision, licensed driving, and legal alcohol consumption, as well as sensation seeking leading to risk-taking behavior (Ward et al., 2021;

Curtin et al., 2018). Therefore, injury prevention interventions must be adjusted for this stage of human development. These adjustments will be powerful, as interventions aimed at improving health and wellbeing during adolescence have been shown to flow into adulthood and onto the next generation (Patton et al., 2016).

This review has synthesized information regarding effective unintentional injury prevention interventions for adolescents, which can inform the economic assessment of the cost/benefit of implementing effective interventions. Such information is vital to encourage government and donor investment in injury prevention for adolescents. However, the findings of this review must be considered within the context of some limitations. The focus of this review was interventions specifically impacting injury among adolescents aged 10–24 years. This excludes interventions known to be effective at reducing injury among the general population (i.e., seat belts, speed cameras, gun control legislation). Excluding self-reported injury may have biased against the inclusion of studies from resource poor settings as these countries may lack formal injury reporting systems. This review was conducted in the English language only and may have therefore excluded studies published in languages other than English. This review included original research published in peer-reviewed literature only; additional evidence may exist in the grey literature, doctoral dissertations or other unpublished documents. Although a detailed search strategy was used, the omission of terms such as 'students,' 'college/uni versity' and 'high school/secondary school' may have impacted the literature identified. Finally, due to the heterogeneous nature of the interventions and analyses used in the included studies, quantitative synthesis of the results was not possible and, although not the initial intention, a meta-analysis was not conducted.

5. Conclusion

Unintentional injury, including road traffic injury, is the leading cause of death and disability among adolescents, with a disproportionate burden in low and middle income countries with LMICs. Evidence regarding effectiveness of interventions can inform investment decisions to reduce injury-related harm, however the evidence does not currently reflect global burden, nor adequately reflect those groups at increased risk. Additionally, while this review yielded a significant body of literature on less lethal injury mechanisms (i.e., sport), there was a total absence of evidence to inform the prevention of adolescent drowning, a leading cause of unintentional injury deaths among 10–24-year-olds globally. With little change in adolescent deaths and DALYs due to injury globally in the last three decades, further research and investment in effective injury prevention interventions for this age group are urgently required.

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7. Implications and Contributions

This study provides evidence to support investment in effective injury prevention interventions for adolescents. However, outside of high-income settings and for injuries other than sport injuries, there are significant evidence gaps regarding effective unintentional injury prevention interventions for adolescents. Future research must also give greater consideration to more disadvantaged adolescents.

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.

Appendix A. Supplementary material

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jsr.2023.03.005.

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Dr Amy E Peden Dr Peden is an injury prevention researcher and advocate, specialising in adolescent injury and drowning prevention, including the epidemiology, risk factor identification and evaluation of drowning prevention interventions. Dr Peden is an [Australian] National Health and Medical Research Council (NHMRC) Emerging Leadership Research Fellow with the School of Population Health Dr Peden has a specific interest in regional communities, alcohol, and social determinants of health. She regularly appears in the media and holds adjunct appointments with Royal Life Saving Society - Australia, James Cook University, the George Institute for Global Health and the Health and Psychology Innovations (HaPI) lab at Griffith University. Dr Peden is also a co-founder of the UNSW Beach Safety Research Group.

Dr Patricia Cullen Dr Cullen's research spans public health, psychology and implementation science. Incorporating multi-methodological approaches, including cohort studies using data linkage, in-depth qualitative inquiries as well as co-design, implementation and evaluation of community led initiatives. Much of Dr Cullen's research centres on implementation and evaluation of optimal care for women and young people, with a focus on integrating trauma-informed care in health settings. Dr Cullen's [Australian] National Health and Medical Research Council (NHMRC) early career fellowship focuses on generating new knowledge of adolescent health trajectories and she is collaborating across three NHMRC Centres of Research Excellence in: Adolescent digital health (APP1134894); Health of Aboriginal and Torres Strait Islander young people (APP1135273); Global adolescent health (APP1171981). Committed to research translation and uptake, Dr Cullen was awarded the 2017 Sax Institute Research Action Award in recognition of research that has significant impact on policy and practice. She has co-authored reports, including government and NGO commissioned reports, multiple submissions to parliamentary enquiries and shared her research in media and social journalism outlets.

Dr Buna Bhandari Dr Bhandari is working as an Assistant Professor of epidemiology at the Central Department of Public Health at Tribhuvan University Institute of Medicine, Kathmandu Nepal. She completed my PhD in Public Health from the School of Population Health of the University of New South Wales, Australia with the focus in the management of non-communicable diseases especially cardiovascular diseases using mHealth. Dr Bhandari is a Bernard Lown Visiting Scholar in Cardiovascular Health at the Department of Global Health and Population, Harvard T.H. Chan School of Public Health. Over the decades, she has worked as an academician and have been involved in teaching-learning activities of undergraduate

Medical, Public health and Nursing students and supervising the research projects of students. Dr Bhandari is passionate about conducting different kinds of epidemiological studies related to cardiovascular diseases, maternal and child health issues like Gender-Based violence, nutrition, and environmental health, policy and program evaluation etc. Dr Bhandari's main objectives are to be a part of different epidemiological studies and strengthen scientific knowledge, thereby contributing to policymaking.

Dr Luke Testa Dr Luke Testa is a Postdoctoral Research Fellow with the Centre for Healthcare Resilience and Implementation Science, Australian Institute of Health Innovation. In 2021 he completed his PhD, in which he evaluated the effectiveness of a hospital avoidance program for acutely unwell aged care facility residents and identified factors impacting health service utilisation in the care of acutely unwell residents. In addition to a PhD, Dr Testa holds a Master of Public Health with distinction and a Master of Research. Dr Testa has expertise in mixed methods research and evaluating models of care.

Miss Amy Wang Amy is a research assistant in the School of Population Health at UNSW Sydney. Miss Wang is working on adolescent injury prevention initiatives.

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Dr Holger Möller Holger is a Research Fellow in the School of Population Health at UNSW, Sydney and a conjoint in the injury division at the George Institute for Global Health. Holger is an epidemiologist with interest and expertise in injury epidemiology, the analysis of large population-based administrative datasets including linked data and quantitative health impact assessment. His main research areas are road transport safety, child injury, injury risk factors, and the cost-effectiveness of active transport. He works across a number of different research studies including the "DRIVE cohort study of 20 822 young drivers", "Understanding burns in Aboriginal and Torres Strait Islander children: treatment, access to services and outcomes (Coolamon study)", "Evaluating consumer product regulatory responses to improve child safety" and the "NSW active transport health model". Holger has worked in Public Health and Epidemiology at universities and in the health service in Germany, England and Australia and has experience in diverse fields such as the quantification of environmental and lifestyle related risk factors using the Global Burden of Disease study methodology, cancer epidemiology, palliative care and environmental and health indicators and injury epidemiology.

Dr Margie Peden Margie's work focuses on how to prevent unintentional injuries, particularly in resource-strapped countries. While road injuries are the biggest issue, Margie's work also canvases other significant problems of drowning, burns and falls, and identifies interventions that could save lives. Her research looks at what works, specifically in developing countries. It will provide evidence on how to prevent injuries before they happen. But it will also hope to look at the post-crash phase, working with nurses – who are the mainstay of healthcare provision in developing countries – to provide optimum treatment management. In some developing countries, traumatic injuries account for up to 70%-80% of the caseloads in emergency rooms. If you can stop these injuries upstream, there are enormous gains for healthcare systems, both financially and in terms of workforce needs. Representing The George Institute for Global Health and South Africa, Margie is a member of the Commonwealth Road Safety Initiative Expert Panel and together with colleagues from Kenya and Canada leads the data analysis for the reports being developed ahead of the 3rd Ministerial level meeting in Sweden in February 2020 and the CHOG meeting in Rwanda. She is also a member of the Academic Expert Group for this Ministerial meeting, a group responsible for making an independent and scientific assessment of the progress made during the Decade of Action for Road Safety. This report is now available here. The Academic Expert Group will also recommend a road safety strategy for the period 2020-2030. Margie is also Chair of the Global Advisory Board for the Malawi Road Safety Research and Implementation Unit at the University of Malawi. Prior to working at The George Institute, she was a nurse and an epidemiologist. She worked in a hospital in Cape Town, South Africa for many years before moving to the National Trauma Research Programme at the South African Medical Research Council. After that she was at the World Health Organization for 17 years, coordinating the Unintentional Injury Prevention unit.

Professor Susan M Sawyer Professor Susan Sawyer holds the inaugural Chair of Adolescent Health, Department of Paediatrics, The University of Melbourne (2005-), which was endowed in 2015 as the Geoff and Helen Handbury Chair of Adolescent Health. She is Director of the Centre for Adolescent Health at the Royal Children's Hospital (2005-), a World Health Organization Collaborating Centre for Adolescent health. The subject of a personal profile in The Lancet (2007), she was inducted into the Victorian Women's Honour Roll in 2013 in recognition of her contribution to adolescent health and medicine. She was awarded the Victorian Premier's Award for Excellence in Mental Health in 2011. In 2016, she was the recipient of the University of Melbourne Engagement Award (Department of Paediatrics) in recognition of sustained community engagement, policy impact and public advocacy and the recipient of its Postgraduate Teaching Award in 2018. She is president of the International Association for Adolescent Health (IAAH) (2017-21). A paediatrician by training, she has helped develop the field of adolescent health, both nationally and internationally. She is the current president of the International Association for Adolescent Health. Nationally, she was instrumental in establishing the Royal Australasian College of Physician's committee on adolescent health and was its inaugural chairman from 2002-2007. This work established the framework that led to the accreditation of Adolescent and Young Adult Medicine as a specialist field of medical practice in Australia. She currently chairs the RACP Advanced Training Committee in Adolescent and Young Adult Medicine (2019-). Her research interests focus on health services for adolescents, with interests in health care quality, developmentally appropriate models of care (eg transition to adult health care) and chronic disease management in adolescence. She has expertise in both quantitative and qualitative research methods.

Professor Rebecca Ivers Scientia Professor Rebecca Ivers is Head, School of Population Health, UNSW Sydney, and honorary Professorial Fellow at the George Institute for Global Health. Ivers leads a global research program focusing on the prevention and management of injury. Trained as an epidemiologist, her research interests focus on the prevention of injury, trauma care, and the research to policy transfer in both high and low income countries. She has a substantial program of research addressing the global burden of injury, with a particular focus on equity and the social determinants of health, taking a life course approach. Her work has a strong focus on implementation and sustainability. Ivers has worked extensively with the World Health Organization, contributing to multiple Good Practice Guides and global advocacy across unintentional injury.