

Trend in injury-related mortality and morbidity among adolescents across 30 countries from 2002 to 2010

Michal Molcho¹, Sophie Walsh², Peter Donnelly³, Margarida Gaspar de Matos⁴, William Pickett⁵

1 Health Promotion Research Centre, NUI Galway, Galway, Ireland

2 Department of Criminology, Bar Ilan University, Ramat Gan, Israel

3 Medical and Biological Sciences, University of St Andrews, St Andrews, Scotland

4 Health Education, Universidade de Lisboa, Lisbon, Portugal

5 Department of Community Health and Epidemiology, Queen's University, Kingston, Canada

Correspondence: Michal Molcho, Health Promotion Research Centre, NUI Galway, University Road, Galway, Ireland, Tel: +0035391493668, e-mail: Michal.molcho@nuigalway.ie

Background: The aim was to examine temporal trends in injury mortality and morbidity across 30 countries in Europe and North America, and the impact of regional geography and adolescent risk behaviours (including substance use and physical fighting) on such trends. **Methods:** Data were obtained for 30 countries in 2002, 2006 and 2010. Mortality data were obtained from the World Health Organization's (WHO) Health for all database. Trends over time were described by WHO Regions using standardized rates comparisons and Poisson regression analyses. **Results:** Injury-related mortality, but not morbidity, declined over time across all countries (from 10 to 8 deaths per 100 000 between 2001 and 2010), with notable differences observed by Regions (e.g. from 48 to 39 deaths in Russia). Risk behaviours included in the models were consistently and significantly associated with injury morbidity, with substance increasing the risk for injury by 1.15 to 1.36 among girls, and physical fighting increasing the risk by 1.21 to 1.31 among boys across WHO Regions. Risk behaviours did not explain the observed temporal trends. **Conclusions:** Injury mortality and morbidity represent different health phenomena. Efforts that have been made to make societies safer for children have seemed to be successful in reducing injury morbidity.

Introduction

Injury is a leading public health problem in adolescents.¹ There is a clear need for effective, evidence-based, policy solutions to address this problem internationally. Analyses of trends in the occurrence of injury, as well as potential causes of such trends, can provide insight into potential interventions. Over the last three decades, declines in fatal childhood injury rates have been documented in some developed countries, attributable to advances in the field of injury prevention aimed at leading causes of mortality (road traffic crashes, drowning, burns, falls and poisonings).^{1,2} Less is known about analogous trends in morbidity, and to our knowledge, models of potential explanations of international trends in adolescent injury have generally been descriptive.

In Europe, changes to the political landscape during the past decade undoubtedly had many impacts on adolescent health, including the occurrence of injury. There are many established individual risk factors for adolescent injury; common ones include substance misuse³ violence,⁴ time engaged in sport⁵ and socioeconomic status.⁶ The rapid political changes experienced in Europe may have impacted the prevalence and perhaps the impact of these leading risk factors. It would be informative for public health to know whether the effects of such etiological factors remained consistent in different Regions of Europe, and whether these factors can explain any observed temporal trends in the occurrence of adolescent injury in these regions.

In this article, we examine international trends in the occurrence of pediatric injury in 30, mainly European, countries. We profiled trends in the occurrence of fatal injury to children aged 1–19 years, then non-fatal injury to young adolescents, between 2002 and 2010. We examined relations between injury and the above risk factors in 12 370 715-year olds from the 30 countries. We expected to observe reductions in injury over time in most countries, as suggested by the literature,^{2,3} and due to the recent emphasis on injury control and safety promotion internationally.⁷ We also expected to observe

variations in temporal trends and perhaps the impact of risk factors by WHO region, with more dramatic changes in new European Union (EU) entrants and the Commonwealth of Independent States (CIS). The article discusses the public health implications of the observed trends and patterns.

Methods

Study design and data sources

This article utilizes data from two sources. Estimates on 'injury mortality' of children aged 1–19 years were obtained from the WHO public registry HFA,⁸ which provided data on rates of unintentional injury deaths. Self-report data from school children aged 11, 13 and 15 years in 30 countries were obtained using records of the three most recent cycles of the Health Behaviour in School-aged Children study (HBSC), with a total sample of 581 838 children. This article focuses only on 15-year olds ($n = 123\,707$).⁹ Response rates varied by cycle and country and were more than 70% for almost all national surveys. Each country team obtained approval to conduct the survey from the ethics review board or equivalent regulatory body. Participation was voluntary, and consent was sought from school administrators, parents and children.

Measures

Injury

The core mortality indicator was age/gender-specific rates of 'unintentional fatal injuries to children aged 1–19 years'. These were calculated per country and year and used to analyse time trends. The core morbidity indicator was individual self-reports of two or more non-fatal injuries during the past 12 months; a standard indicator of repeated injury occurrence.¹⁰ Rates were either obtained directly (mortality) or calculated (morbidity) for three recent study years (2002, 2006 and 2010).

Table 1 Trends in mortality and morbidity due to injury by WHO region and country, 2002–10

WHO Region Country	Age/sex standardized rate of injury per year by country, and trends in rate over time											
	Mortality: Fatal injuries per 100 000 in ages 1–19 years ^a						Morbidity: Multiple injuries per 100 in ages 11–15 years ^b					
	2001–02	2005–06	2009–10	B	Trend Se	P	2001–02	2005–06	2009–10	B	Trend se	P
Old European Union (pre-2004)												
Austria	13	11	9	−0.046	0.05	0.55	24	16	26	−0.010	0.006	0.10
Belgium	–	11	11	–	–	–	21	19	21	−0.003	0.004	0.47
Denmark	10	8	8	−0.029	0.06	0.72	23	27	25	0.010	0.005	0.08
Finland	13	12	9	−0.044	0.05	0.56	13	15	16	0.028	0.006	<0.0001
France	13	9	8	−0.063	0.06	0.47	27	20	19	−0.044	0.005	<0.0001
Germany	11	8	6	−0.076	0.06	0.44	29	23	26	0.012	0.005	0.03
Greece	13	11	10	−0.033	0.05	0.64	21	15	17	−0.025	0.006	<0.0001
Ireland	14	11	13	−0.010	0.05	0.88	21	16	15	−0.038	0.007	<0.0001
Italy	10	8	7	−0.045	0.06	0.60	21	21	19	−0.008	0.006	0.19
Netherlands	8	6	5	−0.060	0.07	0.56	14	17	19	0.043	0.007	<0.0001
Norway	11	9	8	−0.040	0.06	0.61	21	22	22	0.006	0.006	0.30
Portugal	16	–	8	–	–	–	21	18	16	−0.033	0.007	<0.0001
Spain	11	9	6	−0.073	0.06	0.44	29	29	34	0.017	0.005	0.0002
Sweden	8	7	6	−0.035	0.07	0.69	17	13	14	−0.025	0.007	0.0002
UK	9	8	6	−0.049	0.06	0.59	26	23	23	−0.016	0.003	<0.0001
New European Union (2004-)												
Croatia	14	12	10	−0.042	0.05	0.57	16	19	17	0.009	0.006	0.125
Czech Republic	14	12	9	−0.054	0.05	0.49	16	19	19	0.027	0.006	<0.0001
Estonia	31	24	14	−0.085	0.04	0.24	14	18	18	0.026	0.007	0.0002
Hungary	12	11	8	−0.049	0.06	0.54	13	18	13	0.0008	0.007	0.91
Latvia	37	24	17	−0.099	0.04	0.22	21	19	32	0.067	0.006	<0.0001
Lithuania	32	29	24	−0.035	0.03	0.48	21	26	23	0.010	0.005	0.05
Poland	15	14	13	−0.018	0.05	0.77	9	9	11	0.029	0.008	0.0003
Slovenia	14	12	9	−0.054	0.05	0.49	19	14	20	0.009	0.006	0.15
Commonwealth of independent states												
Russia	48	39	32	−0.051	0.05	0.32	19	18	21	0.007	0.005	0.19
Ukraine	32	28	21	−0.051	0.03	0.38	12	18	14	0.013	0.007	0.05
Other countries												
Canada	–	–	–	–	–	–	29	20	23	−0.036	0.004	<0.0001
Israel	15	9	5	−0.136	0.06	0.27	27	29	26	−0.005	0.005	0.30
Switzerland	11	09	8	−0.040	0.06	0.61	22	21	20	−0.013	0.006	0.02
TFYR-Macedonia	12	–	11	–	–	–	10	10	5	−0.088	0.010	<0.0001
USA	–	–	–	–	–	–	27	21	23	−0.019	0.005	<0.0001
All countries	17	14	11	−0.054	0.009	<0.0001	21	20	20	−0.003	0.001	0.002

a: Standardized to the standard European population.¹⁴

b: Standardized to the entire HSC participant population for 2002–10.

Table 2 Trends in mortality and morbidity due to injury by WHO region and gender, 2002–10

Region Gender	Age standardized rate of injury per year, and trends in rate over time											
	Mortality: Fatal injuries per 100 000 in ages 1–19 years ^a						Morbidity: Multiple injuries per 100 in ages 11–15 years ^b					
	2002	2006	2010	B	Trend Se	P	2002	2006	2010	B	Trend se	P
Old European Union (pre-2004)												
Boys	15	13	11	−0.046	0.01	0.0009	28	25	25	−0.011	0.002	<0.0001
Girls	7	5	4	−0.042	0.02	0.04	18	17	17	−0.002	0.002	0.37
New European Union (2004-)												
Boys	21	19	16	−0.064	0.01	<0.0001	20	22	23	0.015	0.003	<0.0001
Girls	9	8	7	−0.051	0.02	0.02	12	14	15	0.033	0.003	<0.0001
Commonwealth of independent states												
Boys	56	46	36	−0.055	0.02	0.04	22	23	21	−0.0002	0.005	0.98
Girls	23	20	16	−0.047	0.03	0.18	12	14	13	0.023	0.007	0.0005
Other countries												
Boys	16	12	9	−0.052	0.03	0.08	28	24	24	−0.025	0.003	<0.0001
Girls	7	5	5	−0.051	0.04	0.21	19	16	18	−0.021	0.004	<0.0001
All countries												
Boys	23	18	15	−0.056	0.01	<0.0001	25	24	24	−0.007	0.001	<0.0001
Girls	9	8	6	−0.048	0.01	<0.0001	16	16	17	0.003	0.002	0.06

Note: Figures in bold represent significant results.

a: Standardized to the standard European population.¹⁴

b: Standardized to the entire HSC participant population ages 11–15 year for 2002–10.

Table 3 Relations between survey cycle (time) and multiple injuries among 15-year olds within WHO Regions participating in the 2002–10 HBSC surveys, accounting for established individual risk factors for adolescent injury

Indicator	Relative risk (95% CI) for multiple injuries							
	EU Pre-2004		EU Post-2004		CIS		Other countries	
	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted	Crude	Adjusted
Males								
N	31 715		14 072		3 713		10 568	
Temporal trend—per 4 year cycle	0.96 (0.93–0.99)	1.05 (1.01–1.09)	1.03 (0.99–1.08)	1.01 (0.94–1.07)	1.02 (0.94–1.11)	1.06 (0.90–1.24)	0.92 (0.88–0.97)	0.96 (0.89–1.03)
Substance use (0–3 types lifetime)	1.23 (1.21–1.26)	1.16 (1.14–1.19)	1.28 (1.23–1.32)	1.15 (1.11–1.20)	1.25 (1.17–1.33)	1.17 (1.08–1.28)	1.25 (1.21–1.30)	1.17 (1.12–1.22)
Physical activity (1—'none' to 7 'daily')	1.19 (1.17–1.21)	1.16 (1.14–1.18)	1.15 (1.12–1.18)	1.11 (1.08–1.15)	1.11 (1.06–1.17)	1.07 (1.02–1.14)	1.17 (1.13–1.20)	1.14 (1.10–1.18)
Physical fighting (1—'none' to 5 '4+times')	1.26 (1.24–1.27)	1.21 (1.19–1.23)	1.26 (1.23–1.29)	1.21 (1.18–1.25)	1.31 (1.26–1.37)	1.27 (1.20–1.34)	1.27 (1.24–1.30)	1.21 (1.17–1.25)
Family affluence (0—'low' to 9 'high')	1.05 (1.03–1.06)	1.04 (1.02–1.06)	1.10 (1.07–1.12)	1.08 (1.05–1.11)	1.11 (1.07–1.16)	1.07 (1.02–1.13)	1.06 (1.03–1.09)	1.04 (0.77–1.42)
Females								
N	33 119		14 888		4 349		11 283	
Temporal trend—per 4 year cycle	1.02 (0.99–1.05)	1.11 (1.06–1.17)	1.13 (1.07–1.19)	1.04 (0.96–1.12)	1.15 (1.03–1.27)	1.19 (0.97–1.46)	0.94 (0.89–0.99)	1.00 (1.92–1.08)
Substance use (0–3 types lifetime)	1.26 (1.23–1.29)	1.20 (1.17–1.23)	1.36 (1.30–1.42)	1.26 (1.20–1.32)	1.22 (1.12–1.32)	1.13 (1.02–1.35)	1.19 (1.15–1.24)	1.16 (1.11–1.21)
Physical activity (1—'none' to 7 'daily')	1.17 (1.15–1.19)	1.17 (1.14–1.19)	1.15 (1.12–1.18)	1.14 (1.10–1.17)	1.10 (1.04–1.17)	1.08 (1.02–1.15)	1.18 (1.14–1.22)	1.17 (1.13–1.21)
Physical fighting (1—'none' to 5 '4+times')	1.32 (1.30–1.35)	1.28 (1.25–1.31)	1.34 (1.29–1.38)	1.29 (1.24–1.34)	1.34 (1.26–1.42)	1.31 (1.19–1.45)	1.29 (1.24–1.33)	1.24 (1.19–1.29)
Family affluence (0—'low' to 9 'high')	1.08 (1.06–1.10)	1.07 (1.05–1.09)	1.09 (1.07–1.12)	1.06 (1.02–1.09)	1.10 (1.04–1.16)	1.05 (0.98–1.13)	1.04 (1.01–1.08)	1.04 (1.01–1.08)

Note: Figures in bold represent significant results.

Risk factors

Variables used in this analysis included time (survey cycle), gender, a composite substance use measure that considered lifetime smoking, drunkenness and cannabis use¹¹; frequency of physical activity⁹; frequency of physical fighting¹² and individual family affluence (FAS).¹³

Analyses

Trends analyses by geographic region were conducted for both mortality and morbidity data. For these analyses, countries were divided into four WHO geographic Regions (EU prior to 2004, EU post-2004, CISs and other countries).

We first modelled temporal trends in the age/gender standardized rates of fatal injury by WHO region and over time using Poisson regression. Time was included here as a linear (continuous) term. Second, for the non-fatal injury outcome, age/gender standardized rates were estimated for adolescents (ages 11–15 years) by HBSC survey cycle for each country using the entire HBSC study population for those years as the standard. We then modelled temporal trends in individual reports of injury among all HBSC participants by country using Poisson regression analyses that modelled 'multiple injuries' as the dependent variable with age, gender and year of survey cycle (continuous) as the independent variables. Models accounted for the clustered nature of the sampling scheme, with individuals nested within schools, through incorporating a conservative design effect of 1.2 to account for the clustered sampling method. The analyses were weighted by sample sizes within each country.

Risk behaviour analysis

Poisson regression analyses were then conducted to predict the occurrence of 'multiple injuries' among 15-year-old HBSC participants. The focus here was on examining regional variations and also explaining any temporal trends observed within the four WHO Regions. Models were built to explore patterns in the individual risk factors for adolescent injury and whether they accounted for

any observed trends. Countries and schools were included as random effects, as a way to compensate for the clustered nature of the sample. All analyses used SAS, V. 9.3.

Results

Mortality trends

There was a consistent decline in the rates of fatal injuries to children aged 1–19 years in all WHO regions. While the outcome was rare and the declines were modest enough that none achieved statistical significance within individual countries, this decline was statistically significant overall, and by gender in the analyses by WHO Region (Table 1).

Morbidity trends

Rates of injury were higher among males than females in all regions, and higher in old EU and 'other' countries. Observed temporal trends varied by WHO Region. Among old EU countries, self-reported injuries declined in six countries, increased in three countries and remained unchanged in six countries. Among the new EU countries, injuries increased in four countries and remained unchanged in four countries, in the CIS region no temporal trend was visible, and among the other countries injuries declined in four countries and remained unchanged in one (Table 2).

Risk factor analysis

In general, each of the risk factors for non-fatal injury included showed the hypothesized relationship, and this with remarkable consistency, in genders and within each WHO Region (Table 3). Confirmed risk factors were engagement in more types of psychoactive substances, more frequent physical activity,⁵ more frequent reports of violence and higher levels of family affluence.⁶ Unexpectedly, risk factors included in the study did not explain observed temporal trends, as time trends for most countries/

regions were not mitigated following simultaneous adjustment for these risk factors.

Discussion

The aim of this article was to examine temporal trends in injury mortality and morbidity. While injuries are one of the leading causes of death among young people globally, the mortality rates in the WHO European region are relatively low compared with other regions.^{1,2} In most countries and regions, childhood mortality rates due to injury decreased since 2002, consistent with existing international reports from developed countries.^{1,2} Such decreases may be the result of an investment in safety,⁷ coupled with improved health services and trauma care.¹

Unlike fatal injuries, no consistent trends were found in injury morbidity, both between and within WHO Regions. Supported by literature,^{3,4} the findings demonstrated that physical fighting and substance use are the main predictors of injury across all regions and in both genders. Participation in physical activity was another risk factor, consistent with previous findings suggesting that the majority of self-reported injuries among young people occur during sport and physical activity.^{5,6} Yet, these risk factors did not provide a consistent explanation for the temporal trends in self-reported injuries among 15-year olds.

Differences in temporal trends observed between the mortality and morbidity indicators are noteworthy. Our findings suggest that fatal and non-fatal injuries are different phenomena, with similar proportions of self-reported even where mortality rates are substantially higher, and with no consistency in the temporal trends for fatal and non-fatal injuries. The external causes of fatal and non-fatal injuries are very different, with most fatal injuries among young people are the result of road traffic injuries, drowning, burns, poisonings and falls.¹ Most self-reported injuries in HBSC are the result of physical activity. Hence, these differences in etiology may account for the divergence in observed patterns predicted by this theory. Another explanation could be found in the measure of self-reported injury that asks children to report medically treated injury. It is possible that the relative lower rates in CIS and New EU countries reflect the access to health care in the community thus biasing the injury reported towards more severe injuries,⁵ resulting in under-reporting of less severe injuries.

Findings of our analysis have some policy implications. First, it is encouraging to see the observed declines in fatal injury across all regions. Clearly, efforts that were made to create a safer environment for children have been effective. Second, the consistency and universality of the risk factors as predictors of injury over and above temporal changes send a clear message to policy-makers in terms of areas for intervention for reduction of injury. For example, programmes that aim at reducing substance use, as well increasing safety in sport will, inevitably reduce the prevalence of injuries. Third, the findings suggest that there is a need to investigate children's access to health care and its effect on self-reported injuries. It is also of importance to continue the efforts to bring down level of injury mortality, in CIS countries in particular.

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Key points

- Injury-related mortality rates in WHO Region for Europe are declining, but no consistent trends were found in relation to injury morbidity.
- Engagement in risk behaviours increases the risk for injury, but does not provide a consistent explanation for temporal trends in injuries.
- Our findings suggest that injury mortality and injury morbidity represent different phenomena indicating that different prevention efforts are required for each phenomenon.

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