Causes of death up to ten years after hospitalisation for self-inflicted, drug/alcohol-related, or violent injury during adolescence: a nationwide cohort study

Annie Herbert, Ruth Gilbert, David Cottrell, Leah Li

Population, Policy & Practice Programme, Great Ormond Street Institute of Child Health, University College London, London, UK (Dr A Herbert, PhD; Prof R Gilbert, MD; Dr L Li, PhD); Department of Behavioural Science and Health, Institute of Epidemiology & Healthcare, University College London, London, UK (Dr A Herbert, PhD); and Leeds Institute of Health Science, Faculty of Medicine and Health, University of Leeds, Leeds, UK (Prof D Cottrell, MA; FRCPsych)

Correspondence to: Dr Annie Herbert, Department of Behavioural Science and Health, Institute of Epidemiology & Healthcare, University College London, London, UK
annie.herbert@ucl.ac.uk

Abstract: 320 (limit 300)
Manuscript: 3,556 (limit 3,000)
Tables: 3
Figures: 3
Supplementary tables: 3
Supplementary figures: 1
References: 30 (limit 30)

Summary

Background: Emergency hospital admission with adversity-related injury (self-inflicted, drug/alcohol-related, violent) affects 4% of 10-19 year olds. Their risk of death in the decade after discharge is twice as high compared to adolescents hospitalised for accident-related injury. We determined how cause of death varied between these groups.

Methods: We compared risks of death in five causal groups (suicide, drug/alcohol-related, homicide, accidental, 'other') up to ten years after discharge following adversity-related or accident-related injury. We used linked hospital admission (to the National Health Service) and mortality data for England (1997-2012) to determine cause-specific risks of death for 10-19 year olds, and to compare risks between adversity- and accident-related index injury after adjustment for age-group, socio-economic status, and chronic conditions.

Findings: Among 333,009 adolescents admitted with adversity-related injury (girls 181,926, boys 181,053), and 649,818 with accident-related injury (girls 166,462, boys 483,356), 4,782 died in the ten years post-discharge (girls 1,312, boys 3,470). Adolescents discharged after adversity-related injury had higher risks of suicide and of drug/alcohol-related death in the next decade than after accident-related injury (adjusted hazard ratios [aHRs] varied from 3·2 [95% CI: 2·7, 3·6] for suicide in boys to 4·7 [3·3, 6·8] for drug/alcohol-related death in girls). Risks of suicide were increased following self-inflicted injury, drug/alcohol related injury, and violent injury (e.g. boys, aHR: 6·2 [5·3, 7·3], 4·5 [3·9, 5·2], 1·4 [1·2, 1·8], respectively vs. accident-related injury). Following each type of index injury, risks of suicide and risks of drug/alcohol-related death were increased by similar magnitudes (e.g. boys with self-inflicted injury vs. accident-related injury, aHR of suicide: 6·2 [5·3, 7·3], drug/alcohol-related injury death: 5·9 [5·0, 7·0]).

Interpretation: Risks of suicide increased after all types of adversity-related injury, as did risks of drug/alcohol-related death by a similar magnitude. Current practice to reduce risks of harm after self-inflicted injury should be extended to drug/alcohol-related and violent injury in adolescence. Prevention should address the substantial risks of drug/alcohol-related death alongside risks of suicide.

Funding: Department of Health Policy programme (reference 109/00017).

Introduction

Evidence from population-based cohort studies suggests that different types of 'adversity-related injury' (self-inflicted [including poisonings], drug/alcohol-related, or violent injury) during adolescence are associated with similar underlying psychosocial problems, including adverse experiences (e.g. maltreatment), poor mental health (e.g. anxiety, depression), and poor social circumstances (e.g. poverty).[1-3] Among the 4% of adolescents (10-19 year olds) who are admitted to hospital with one of these types of adversity-related injury in England, approximately three-quarters of girls and one-third of boys are admitted with injuries related to multiple types of adversity.[4] Despite this apparent overlap between self-inflicted, drug/alcohol-related, and violent injury, most research in these adolescents has focused on specific types of adversity-related injury. A previous study of adolescents admitted to hospital in England as an emergency with any adversity-related injury reported that 1 in 136 girls (7·3 per 1,000) and 1 in 64 boys (15·6 per 1,000) died within the ten years after discharge, and that these risks were similar whether the initial injury was self-inflicted, drug/alcohol-related, or violent.[5] These ten-year risks were approximately twice the risks for adolescents discharged after accident-related injury (girls 3·8 per 1,000 and boys: 6·0 per 1,000) or for the general population of adolescents (girls 3·0 and boys: 3·0).

Despite common underlying psychosocial problems and elevated mortality risks among adolescents with any of these three types of adversity-related injury, UK national clinical guidelines recommend different approaches to psychosocial assessment and intervention to reduce future harm.[6-8] For example, guidelines for managing self-inflicted injury presenting to hospital recommend admission of patients younger than 16 years and assessment of psychosocial circumstances and suicide risk at all ages.[6,7] Guidelines for drug- or alcohol- related presentations do not specifically address psychosocial needs of adolescents.[8] No UK guidelines exist for responding to violent injury. A further issue is that clinical management to reduce the risk of further harm after self-inflicted injury focuses on risks of recurrent self-harm, despite evidence for increased risks of other adverse outcomes.[9] A cohort study of 15-24 year olds presenting to a hospital in Oxford with self-inflicted injury in 1978-1997 reported increased mortality due to respiratory disorders, circulatory disorders, and accidents, as

well as suicide, during the subsequent 20 years.[9] No comparable estimates have been published for risks of harm following drug/alcohol-related or violent injury (see panel 'Research in Context').

This study aims to inform preventive strategies for reducing risks of future harm for adolescents who are discharged from hospital after self-inflicted, drug/alcohol-related, or violent injury. Given standard practice to reduce risks of repeated self-harm or suicide after discharge following self-inflicted injury, we examined, for girls and boys separately, whether risks of suicide difference between adolescents discharged following drug/alcohol-related and violent injury. Second, among girls and boys respectively, we compared risks of cause-specific death (suicide, drug/alcohol-related, homicide, accidental, and other) up to ten years from discharge after each type of index injury, including accident-related injury.

Methods

Study design

We used Hospital Episode Statistics (HES) data, which contain all emergency (acute, unplanned) admissions to the National Health Service (NHS) in England (April 1997-March 2012), including to independent sector providers paid for by the NHS.[10] Approximately 98-99% of hospital activity in England is funded by the NHS,[11] and so these data captured nearly all admitted adolescents. As we used a standard, de-identified HES extract from NHS Digital (formerly known as the Health and Social Care Information Centre), ethics approval was not required.[12]

We derived a cohort of adolescents (aged 10-19 years inclusive) who were admitted for injury (the index injury), and categorised them as 'adversity-related injury' (comprising non-mutually exclusive groups of self-inflicted, drug/alcohol-related, or violent injury; irrespective of whether the injury was also accident-related) or 'accident-related injury' (where there was no recorded adversity-related injury). Therefore, adversity-related injury and accident-related injury were two mutually exclusive groups. Deaths within the cohort were evaluated in five 'causal' groups: suicide, drug/alcohol-related,

homicide, accidental, or 'other'. We compared risks of death (total and by cause) up to ten years following discharge from admission for adversity-related injury (exposure) with risks after accident-related injury (comparator).

We excluded adolescents who did not have sex recorded (885; 0·08%), died during the index admission (1,877; 0·17%), had no valid discharge date (372; 0·03%), or were admitted with injury related to neither adversity nor accidents (94,407; 8·9%; the majority of these latter adolescents were admitted primarily for chronic conditions or complications of surgery).[4]

Study cohort and exposures

Self-inflicted, drug/alcohol-related, violent, and accident-related injuries were identified using ICD-10 codes in HES data (i.e. characteristics that were identified and recorded by clinicians). Details of classification of injury and descriptive statistics of the cohort have been reported elsewhere.[4,5] Briefly, 333,009 adolescents who had at least one adversity-related injury (181,926 girls, 151,083 boys; 20·3% and 24·0% of which had an injury that was also accident-related), and 649,818 with at least one accident-related injury but no adversity-related injury (166,462 girls, 483,356 boys) were identified (Supplementary Figure S1).[5]

Table 1 shows that the most frequent type of injury among girls and boys was drug/alcohol-related followed by self-inflicted injury in girls and violent injury in boys. We have previously reported that the peak age group for adversity-related injury was 15-17 years old for girls (47%) and 18-19 years old for boys (62.%), but for accident-related injury it was 10-14 years for girls (54%) and boys (62%). Compared with adolescents admitted with accident-related injury, those admitted for adversity-related injury were more likely to be in the in the most deprived category, or to have a chronic condition (Herbert *et al* 2015, Table 1).[5]

Outcomes

The primary outcome was cause-specific death between one day and ten years after discharge from the index injury admission. We identified deaths using Office for

National Statistics (ONS) mortality data linked to HES (within NHS Digital). We used any ICD-9 or -10 codes in the mortality data (based on the underlying and up to 15 other contributing causes recorded in the death certificate) to categorise deaths into five 'causal' groups (Supplementary Table S1). As Figure 1 illustrates, suicide, drug/alcohol-related, and homicide were not mutually exclusive, but these three groups (i.e. adversity-related deaths), accidental (no codes for adversity-related death, but codes for accidental causes) and 'other' deaths (no codes for adversity-related or accidental deaths) were mutually exclusive. As advised by the ONS, undetermined causes of death (codes E980-E989, Y1-Y34; n=483) were classified as suicide (accounting for 38·1% of all suicides).[13] Deaths with codes indicating an adjourned inquest (U50·9; n=130) were categorised as homicide (80·2% of all homicides).

Demographic and clinical factors

Covariates were included in the analyses, based on previous findings of their relationship with adversity-related injury and death, including sex, age, socio-economic status (SES), and chronic conditions.[5] Age was grouped (10-15, 16-17, 18-19 years) to reflect different recommendations in UK national guidelines for management of self-harm or alcohol misuse according to age, and different stages of social development.[6-8] SES was categorised according to Index of Multiple Deprivation scores based on residential postcode,[14] using quintile cut-off values for England. An adolescent was classified as having an underlying chronic condition if HES records for the index injury admission or any admissions in the previous year included one of a cluster of ICD-10 codes for chronic conditions (Hardelid *et al*, 2013; Appendix Table 6·3·2).[15] Of the 117,453 adolescents with adversity-related or accident-related injury who had a chronic condition, 93,592 (79·7%) had a physical condition (data not shown). The most common physical condition was chronic respiratory disorder (e.g. asthma, 39·8% to 55·4% by sex and type of injury).[5]

Statistical analyses

All analyses were conducted in Stata/SE 12 (StataCorp), and separately for girls and boys.

We first derived numbers (and proportions) of deaths (total and by cause) in the ten years post-discharge after adversity-related (self-inflicted, drug/alcohol-related, or violent) or accident-related index injury. As statistical disclosure rules required us not to publish counts <10 we did not present exact numbers of homicides for certain groups.

We determined unadjusted cumulative risks and 95% confidence intervals (CIs) of deaths for each cause of death over the ten years following discharge from the index injury admission. The cumulative risk of death by cause of death was estimated as a cumulative incidence function, which accounted for other 'competing' causes (e.g. for suicide, competing causes included homicide, drug/alcohol-related, accidental and other).[16] For reference, we present unadjusted ten-year cumulative risks and 95% CIs by cause of death and type of index injury, sex, and age-group (Supplementary Table S2). We also estimated total and cause-specific risks of death for the general population of 10-19 year olds in England in 1997-2012, using publicly available ONS life-tables for total mortality and suicide, and bespoke life-tables for drug/alcohol-related and accidental deaths provided to us by the ONS (according to ICD codes in Supplementary Table S1).[17 -19]

We fitted Fine & Gray models[16] to estimate the relative risks of total and cause-specific mortality following adversity-related index injury, adjusted for covariates and taking into account competing risks of other causal groups. The exposure was type of index injury, and covariates included age-group, SES, and chronic condition status. 'Sub-hazard ratios' (SHRs) of each cause of death were estimated for adversity-related injury (vs. accident-related injury), age-groups 16-17 and 18-19 years (vs. 10-15 years), each level of SES (vs. least deprived), and chronic condition (vs. none). To compare risks following each type of adversity-related injury, we fitted the models as above but where the exposure was self-inflicted, drug/alcohol-related, and violent injury, respectively (each vs. accident-related injury).

Finally, we assessed whether the finding that increased risks of suicide and drug/alcohol-related deaths following self-inflicted or drug/alcohol-related injury was due to the 'overlap' between these two types of index injury (73% of girls and 44% of boys with either type had both types),[5] or the overlap between suicide and drug/alcohol-

related deaths (~12% of deaths that were either suicide or drug/alcohol-related, were both [Figure 2]). We fitted the Fine & Gray models as above, but where the exposure was the three different combinations of self-inflicted and drug/alcohol-related injury (vs. accident-related injury), and the outcome was suicide, drug/alcohol-related death, and each combination of these types of death, respectively (further details within footnotes of Supplementary Table S3).

We checked model assumptions using log-log plots of the Kaplan-Meier estimate of the survival function and the link test, and assessed their goodness-of-fit using plots of the Nelson-Aalen estimate of the cumulative hazard function against Cox-Snell residuals.[16]

Results

By ten years after discharge from admission for the index injury, there were 2,415 deaths (girls 873, boys 1,542) after adversity-related injury and 2,367 deaths (girls 439, boys 1,928) after accident-related injury (Figure 1, Table 1). After adversity-related index injury, nearly two-thirds (63·9%, n=1,046) of the deaths were related to suicide, drug/alcohol use, or homicide, compared with only one-third (33·6%, n=796) after accident-related index injury (Figure 1, Table 1). The proportions of deaths related to suicide, drug/alcohol use, or homicide were similar between girls and boys after adversity-related injury (girls 59·3% [n=518], boys 66·5% [n=1,025]), but lower for girls than boys after accident-related injury (girls 19·4% [n=85], boys 36·9% [n=711]) (Table 1). The most frequent causes of death after accident-related index injury were 'other' (overall 37·1% [n=877]; girls 59·2% [n=260], boys 32·0% [n=617]) and accidental (29·3% [n=694]; girls 21·4% [n=94], boys 31·1% [n=600]) (Figure 1, Table 1).

Two thirds of all accidental deaths, 67·8% (n=759) were recorded as transport accidents; this proportion did not differ according to type of index admission (data not shown). Among deaths due to other causes, the most common causes were related to

neurological conditions (30·9%, n=473) or cancer/blood disorders (25·1%, n=384; of nine possible groups of ICD codes relating to systems within the body).[15]

Risks of total and cause-specific deaths by type of index injury

Adversity-related vs. accident-related index injury

Ten-year cumulative risks of total death after adversity related index injury were 7·3 per 1,000 (or 1 per 137) girls (95% CI: 6·8 to 7·8 per 1,000) and 15·6 per 1,000 (or 1 per 64) boys (14·8 to 16·4 per 1,000) (Figure 2, Supplementary Table S2). Cumulative risks were lower after accident-related index injury (girls 3·7 per 1,000, 3·4 to 4·1; boys 6·0, 5·7 to 6·3).

The increased risks of death after an adversity-related compared with accident-related injury were due to substantially higher risks of suicides and drug/alcohol-related deaths at all time-points after the index injury (Figure 2). After adjustment for other covariates, risks of suicides and drug/alcohol-related deaths were three to five times higher following discharge from adversity-related injury admission (Table 2).

Self-inflicted, drug/alcohol-related, and violent index injury

Ten-year risks of suicide were similar after hospital discharge following self-inflicted index injury and drug/alcohol-related index injury (girls 2·9 vs. 2·5 per 1,000; boys 9·8 vs. 7·2; Figure 3, Supplementary Table S2). Compared with adolescents discharged after accident-related injury, risks of suicide were increased five- to six-fold for adolescents discharged after self-inflicted or drug/alcohol-related injury (Table 3 shows sub-hazard ratios adjusted for covariates; e.g. for boys the adjusted SHR of suicide after self-inflicted injury was 6·20 [5·27, 7·30]and after drug/alcohol-related injury 4·51 [3·89, 5·24]). Risks of suicide were increased after self-inflicted and after drug/alcohol-related injury, whether the index injury was for either one of these types of injury only, or both (Supplementary Table S3; i.e. comparing between rows, per sex).

Ten-year risks of suicide and of drug/alcohol-related death were similar after each type of index injury. These risks were highest after self-inflicted or drug/alcohol-related

index injury (Figure 3; Supplementary Table S2). For example, after self-inflicted injury, the ten-year risk of suicide for girls was 2·9 per 1,000, whereas the ten-year risk of drug/alcohol-related death was 2·7 per 1,000 (Figure 3, Supplementary Table S2). After adjustment for covariates, the increased risks of suicide after self-inflicted and after drug/alcohol-related index injury (vs. accident-related injury) were similar to the risks of drug/alcohol-related death. For example, among boys discharged after self-inflicted injury compared with after accident-related injury, the adjusted SHR was 6·20 [5·27, 7·30] for suicide and 5·91 [4·96, 7·03], for drug/alcohol-related death) (Table 3). These adjusted SHRs were similar whether the death was related to suicide but not drugs/alcohol, drugs/alcohol but not suicide, or both causes (Supplementary Table S3; i.e. comparing between columns).

Socio-demographic and clinical covariates

Boys aged 18-19 years who were discharged after self-inflicted injury or drug/alcohol-related injury had the highest risks of death due to any cause (ten-year risks: 30·4 per 1,000, or 1 per 33, after self-inflicted injury, 25·1 per 1,000, or 1 per 40, after drug/alcohol related injury; Supplementary Table S2). These risks were substantially higher than after accident-related injury (8·8 per 1,000) or for the general population of 18-19 year old boys (8·9 per 1,000). These risks were driven by high risks of suicide and drug/alcohol-related death.

Adolescents aged 18-19 years had twice the mortality risk compared with 10-15 year olds, due to increased risks of suicide and drug/alcohol-related deaths among older girls and boys, and increased risks of accidental deaths among older boys (Table 2; Table 3). Low SES (i.e. most deprived) was associated with increased risks of total and cause-specific mortality, apart from suicide in boys, in whom low SES was associated with a decreased risk of suicide.

Adolescents with a chronic condition (vs. none) had a 3- to 4-fold increased risk of death due to any cause, and a 10- to 12-fold increased risk of death due to causes other than adversity or accidents, regardless of the type of index injury (Table 2). For example, for 18-19 year old boys discharged after an adversity-related index injury, the

ten-year risk of death due to any cause was 37·5 per 1,000 given a chronic condition and 14·8 per 1,000 given none (data not shown). For 18-19 year old boys discharged after accident-related injury, these risks were 17·5 and 8·8 per 1,000 respectively.

Discussion

This retrospective cohort study determined cause-specific risks of death up to ten years after adolescents were discharged from the NHS in England following injury related to 'adversity' (self-harm, drug/alcohol misuse, violence) or accidents. Within ten years after discharge following adversity-related injury 1 per 137 girls and 1 per 63 boys had died. We found that suicide, drug/alcohol-related deaths, and a small number of homicides accounted for 61% of all deaths ten years after adversity-related injury, but only 35% of deaths after accident-related injury. Second, we showed that risks of suicide were all increased following self-inflicted injury, drug/alcohol-related injury, and following violent injury. These risks were highest for 18-19 year old boys. Third, the risks of suicide were similar to those of drug/alcohol-related deaths regardless of whether the adversity-related index injury was self-inflicted, drug/alcohol-related, or violent. Fourth, adolescents with an underlying chronic condition at the index injury admission (10-15%)[5] were at increased risk of all causes of death, independently of the type of adversity or accident-related injury or age at admission.

Strengths and limitations

The main strength of our study is the use of linked NHS emergency admissions and mortality data, which included all injury admissions in England linked to subsequent mortality reacords in England and Wales over 15 years.[13] The population-based cohort of nearly one million 10-19 year olds allowed us to compare risks of cause-specific mortality between different types of index injury admissions. We used time-to-event statistical methods to estimate risks whilst taking into account censoring of outcomes and competing risks of different causes of death.[16] Although we combined index injury admissions across a 15-year period, our conclusions were not sensitive to calendar period (e.g. boys in 1997, adjusted SHR of suicide for adversity-related vs. accident-related injury [95% CI]: 2·6 [1·7, 3·9]; corresponding SHR for boys in 2012: 3·2 [2·2, 4.7]; data not shown).

One limitation is that ICD codes used to define adversity-related injury and deaths tend to have high specificity but low sensitivity.[20-22] The potential misclassification of exposure (i.e. self-inflicted, drug/alcohol-related, or violent injury, misclassified as accident-related injury) and outcomes (i.e. suicide, drug/alcohol-related deaths, or homicides, misclassified as accidental or other deaths) may induce bias in the estimates of their associations, which is likely to under-estimate the increased risks of suicide and drug/alcohol-related deaths after adversity-related injury relative to after accident-related injury. To minimise this potential bias we included codes for undetermined intent and adjourned inquests in the definitions of suicide and homicide, respectively. The prevalence of chronic conditions recorded by codes at the index injury admission or at hospitalisation during the previous year may be under-ascertained, particularly to the presence of chronic mental health conditions.

A further limitation is potential linkage error between HES and ONS mortality data. One of the few studies that have investigated linkage errors in HES data showed high missed match rates (4.1%) that were higher for males and ethnic minorities.[22] Linkage error between HES and ONS mortality data would favour underestimation of mortality rates.[22] Lastly, the study was likely under-powered to detect differences in the risks of homicide between index injury groups.

Comparison with other studies

Our main finding of similarly increased risks of suicide death following self-inflicted injury and following drug/alcohol related injury has not been previously reported. We report lower ten-year risks of death after admission with self-inflicted injury (girls: 7.7 per 1,000, boys: 24.1 per 1,000; Supplementary Table S2) than the 20-year mortality rates after presentation with self-inflicted injury reported by Hawton *et al* (girls: 17 per 1,000, boys: 50 per 1,000).[9] These differences may be explained by different lengths of follow-up between the two studies, and different age-ranges for exposure (current study: 10-19y vs. Hawton *et al*: 15-25y) and for deaths (10-29y vs. 15-44y). In Hawton *et al*'s study, 60·0% of deaths in girls and 45·6% of those in boys were from suicide (including deaths of undetermined intent and drug/alcohol-related suicides),[9] compared with 39·8% and 43·2% in our study (Table 1).

Implications for practice, policy, and research

Our findings suggest that specialist psychosocial assessment by a child and adolescent mental health professional, which is part of recommended standard practice for self-inflicted injury in the UK, should be considered for adolescents presenting with drug/alcohol-related or violent injury. The need for a consistent approach targeting all three adversity-related injury groups is supported by previous evidence of their common underlying psychosocial problems, the overlap among the same admitted adolescents,[4] and the inter-relationship between related behaviours into young adulthood, particularly self-harm and drug/alcohol use.[24-26] Clinical and public health strategies need to be extended to include reducing risks of death related to drugs/alcohol, which are just as high as risks of suicide death. If it were possible to completely eradicate the excess mortality risk associated with adversity-related injury among hospitalised adolescents, we could have expected 857 fewer suicide and drug/alcohol-related deaths in our cohort (girls: 392 [219 drug/alcohol-related deaths], boys: 683 [394]; based on the estimated relative risks in Table 2). Among 16-19 year olds, the burden of suicides in the decade after adversity-related injury represented approximately 10-25% of suicides expected in the general population during the same follow-up (based on ten-year risks in Supplementary Table S2, and ~3-4% of the general population of 16-19 year olds being admitted with adversity-related injury).[4]

Findings from the current study may be generalised to other UK countries that have similar rates of hospitalisations during adolescence for adversity-related injury,[15] and similar rates of mortality through intentional injuries.[29]

There needs to be more investment in interventions for reducing harm after all types of adversity-related injury, whether self-inflicted, drug/alcohol-related, or violent. Risks of deaths through causes both related to mental health (suicide, drugs/alcohol) and potentially not related to mental health (accidents, other) are substantially increased in adolescents admitted with chronic conditions, and mechanisms of effective interventions may differ for this sub-group. The evidence base for how public health bodies and health services should respond to the common manifestation of distress in vulnerable adolescents of adversity-related injury is weak,[28-30] and there

is a need for the development of potentially effective interventions and then evaluation through large trials to determine what works and for whom.

Role of funding source

This study was funded by the Policy Research Unit in the Health of Children, Young People and Families (funding reference 109/00017), which is funded by the Department of Health Policy Research Programme. The funder had no role in the interpretation or reporting of the results.

Contributors

AH, RG, and LL conceived and designed the study. AH analysed the data and drafted the first version of the article. AH, RG, DC, and LL interpreted the data, revised the article critically for important intellectual content, and approved the final version to be published.

Conflicts of interest

None to declare.

Acknowledgements

We would like to thank members of the Policy Research Unit in the Health of Children, Young People and Families: Catherine Law, Russell Viner, Miranda Wolpert, Amanda Edwards, Steve Morris, Helen Roberts, Terence Stephenson, and Cathy Street. We would like to thank Pia Hardelid for her advice on coding chronic conditions in Hospital Episode Statistics data, and Arturo González-Izquierdo for discussions of this work. We also acknowledge support from the Farr Institute of Health Informatics Research and the Biomedical Research Centre at the University College London Great Ormond Street Institute of Child Health.

Data sources

Hospital Episode Statistics data can be accessed by researchers applying to NHS Digital (previously the Health and Social Care Information Centre for England).

Bespoke extracts and tabulations of mortality data for England and Wales are available to order from the ONS (subject to legal frameworks, disclosure control, resources and agreement of costs, where appropriate). Such enquiries should be made to the mortality team at mortality@ons.gsi.gov.uk.

References

1. Hawton K, Rodham K, Evans E, Weatherall R. Deliberate self harm in adolescents: self report survey in schools in England. *Bmj* 2002; **325**(7374): 1207-11.
2. Wang RH, Hsu HY, Lin SY, Cheng CP, Lee SL. Risk behaviours among early adolescents: risk and protective factors. *Journal of advanced nursing* 2010; **66**(2): 313-23.
3. Viner RM, Ozer EM, Denny S, et al. Adolescence and the social determinants of health. *Lancet* 2012; **379**(9826): 1641-52.
4. Herbert A, Gilbert R, Gonzalez-Izquierdo A, Li L. Violence, self-harm and drug or alcohol misuse in adolescents admitted to hospitals in England for injury: a retrospective cohort study. *BMJ open* 2015; **5**(2): e006079.
5. Herbert A, Gilbert R, Gonzalez-Izquierdo A, Pitman A, Li L. 10-y Risks of Death and Emergency Re-admission in Adolescents Hospitalised with Violent, Drug- or Alcohol-Related, or Self-Inflicted Injury: A Population-Based Cohort Study. *PLoS medicine* 2015; **12**(12): e1001931.
6. National Institute for Health and Clinical Excellence. Self-harm: longer term management [Clinical Guideline 133]. London: National Institute for Health and Clinical Excellence; 2011.
7. National Insitute for Clinical Excellence. Self-harm in over 8s: short-term management and prevention of recurrence [Clinical Guideline 16]. 2004.
8. Bekkering GE, Aertgeerts B, Asueta-Lorente JF, et al. Practitioner review: evidence-based practice guidelines on alcohol and drug misuse among adolescents: a systematic review. *Journal of child psychology and psychiatry, and allied disciplines* 2014; **55**(1): 3-21.
9. Hawton K, Harriss L. Deliberate self-harm in young people: characteristics and subsequent mortality in a 20-year cohort of patients presenting to hospital. *The Journal of clinical psychiatry* 2007; **68**(10): 1574-83.
10. Health and Social Care Information Centre. Hospital Episode Statistics. 2014. http://www.hscic.gov.uk/hes (accessed 28th August 2014.
11. National Audit Office. Healthcare across the UK: A comparison of the NHS in England, Scotland, Wales and Northern Ireland., 2012.
12. Medical Research Council and NHS Health Research Authority. Do I need NHS REC approval? 2015. http://www.hra-decisiontools.org.uk/ethics/ (accessed 18th September 2015.
13. Office for National Statistics. Mortality metadata, 2015.
14. Health and Social Care Information Centre. Inpatient HES Data Dictionary. Leeds: Health and Social Care Information Centre, 2010.
15. Hardelid P, Dattani N, Davey J, Pribramska I, Gilbert R. Overview of child deaths in the four UK countries. London, 2013.
16. Cleves MA. An introduction to survival analysis using Stata. 3rd ed. ed. College Station, Tex.: Stata; 2010.
17. Office for National Statistics. National Life Tables: England. 2015.
18. Office for National Statistics. Table 1: Suicide registrations in the United Kingdom. 2016. http://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/datasets/suicidesintheunitedkingdomreferencetables (accessed 7th September 2016.
19. Office for National Statistics. Deaths from specific grouped causes, England, 1997 to 2012

. 2017.
https://www.ons.gov.uk/peoplepopulationandcommunity/birthsdeathsandmarriages/deaths/adhocs/006513deathsfromspecificgroupedcausesengland1997to2012 (accessed 7th February 2017.

20. McKenzie K, Harrison JE, McClure RJ. Identification of alcohol involvement in injury-related hospitalisations using routine data compared to medical record review. *Australian and New Zealand journal of public health* 2010; **34**(2): 146-52.
21. Patrick AR, Miller M, Barber CW, Wang PS, Canning CF, Schneeweiss S. Identification of hospitalizations for intentional self-harm when E-codes are incompletely recorded. *Pharmacoepidemiology and drug safety* 2010; **19**(12): 1263-75.
22. Wood DM, Conran P, Dargan PI. ICD-10 coding: poor identification of recreational drug presentations to a large emergency department. *Emergency medicine journal : EMJ* 2011; **28**(5): 387-9.
23. Hagger-Johnson G, Harron K, Fleming T, et al. Data linkage errors in hospital administrative data when applying a pseudonymisation algorithm to paediatric intensive care records. *BMJ open* 2015; **5**(8): e008118.
24. Mars B, Heron J, Crane C, et al. Clinical and social outcomes of adolescent self harm: population based birth cohort study. *Bmj* 2014; **349**: g5954.
25. Moran P, Coffey C, Romaniuk H, Degenhardt L, Borschmann R, Patton GC. Substance use in adulthood following adolescent self-harm: a population-based cohort study. *Acta psychiatrica Scandinavica* 2015; **131**(1): 61-8.
26. Swanepoel A. Fifteen-minute consultation: safety assessment prior to discharge of patient admitted for self-harm. *Archives of disease in childhood Education and practice edition* 2016; **101**(6): 287-91.
27. Herbert A, Gonzalez-Izquierdo A, McGhee J, Li L, Gilbert R. Time-trends in rates of hospital admission of adolescents for violent, self-inflicted or drug/alcohol-related injury in England and Scotland, 2005-11: population-based analysis. *J Public Health (Oxf)* 2016.
28. Hawton K, Witt KG, Taylor Salisbury TL, et al. Interventions for self-harm in children and adolescents. *Cochrane Database Syst Rev* 2015; **12**: CD012013.
29. Snider C, Lee J. Youth violence secondary prevention initiatives in emergency departments: a systematic review. *Canadian Journal of Emergency Medicine* 2009; **11**(2): 161-8.
30. Newton AS, Dong K, Mabood N, et al. Brief emergency department interventions for youth who use alcohol and other drugs: a systematic review. *Pediatric emergency care* 2013; **29**(5): 673-84.

Figure 1: Numbers and proportions of deaths by reported cause

Circles represent proportions and are drawn to scale within each figure (i.e. type of injury). Accidental death: codes for accidents and no codes for adversity in death certificate; Other death: no codes for accidents or adversity in death certificate.

Figure 2: Cumulative risk of cause-specific death over time, by sex and adversity-related or accident-related index injury at admission

Drug/alc = Drug/alcohol-related; Acc = Accidental; Oth = Other; 'Suicide' includes all suicides, whether homicide or drug/alcohol-related death were also implicated or not; Drug/alc death includes only drug/alcohol-related deaths where suicide was not also implicated; 'Homicide' includes only where suicide or drug/alcohol-related death was not also implicated. Here cumulative risks are cumulative incidence functions.

Figure 3: Ten-year cumulative risk of cause-specific deaths, by sex and type of index injury

Drug/alc = Drug/alcohol-related; Acc = Accidental; Oth = Other;

Table 1: Number and proportion of cause-specific deaths within ten years after index injury admission, by sex and type of index injury

		Numbers of deaths by cause (row %)					
Type of injury at index admission	**Discharged**	**Total deaths**	**Adversity-related***	**Suicide**	**DA**	**Accidental**	**Other**
Girls	348 388	1 312 (100·0)	603 (46·0)	361 (27·5)	319 (24·3)	228 (17·4)	481 (36·7)
Accident-related	166 462	439 (100·0)	85 (19·4)	47 (10·7)	41 (9·3)	94 (21·4)	260 (59·2)
Adversity-related	181 926	873 (100·0)	518 (59·3)	314 (36·0)	278 (31·8)	134 (15·3)	221 (25·3)
Self-inflicted	131 739	651 (100·0)	408 (62·7)	259 (39·8)	210 (32·3)	93 (14·3)	150 (23·0)
DA	163 888	776 (100·0)	464 (59·8)	283 (36·5)	250 (32·2)	117 (15·1)	195 (25·1)
Violent	13 262	54 (100·0)	25 (46·3)	10 (18·5)	16 (29·6)	11 (20·4)	18 (33·3)
Boys	634 439	3 470 (100·0)	1 736 (50·0)	903 (26·0)	861 (24·8)	891 (25·7)	843 (24·3)
Accident-related	483 356	1 928 (100·0)	711 (36·9)	375 (19·5)	311 (16·1)	600 (31·1)	617 (32·0)
Adversity-related	151 083	1 542 (100·0)	1 025 (66·5)	528 (34·2)	550 (35·7)	291 (18·9)	226 (14·7)
Self-inflicted	44 621	704 (100·0)	526 (74·7)	304 (43·2)	276 (39·2)	92 (13·1)	86 (12·2)
DA	85 421	1 112 (100·0)	775 (69·5)	418 (37·6)	424 (38·1)	183 (16·5)	154 (13·8)
Violent	70 594	460 (100·0)	268 (58·0)	120 (26·1)	135 (29·2)	122 (26·4)	70 (15·2)

DA = Drug/alcohol-related

*Suicides, drug/alcohol-related deaths, and homicides. These deaths were not mutually exclusive. Numbers and proportions are not reported for homicides due to small counts.

Table 2: Relative risk of cause-specific death within 10 years after adversity-related index injury (vs. accident-related injury), adjusted for age-group, socio-economic status, and chronic condition status, by sex (multivariable analyses)

	Cause of death, Adjusted sub-hazard ratio (95% Confidence Interval)									
Characteristic at index injury admission	**All deaths**		**Suicide**		**DA death**		**Accidental death**		**Other death**	
Girls										
Adversity- (vs. accident-related) injury	**1·51**	**(1·34 to 1·71)**	**4·54**	**(3·25 to 6·36)**	**4·71**	**(3·28 to 6·76)**	**1.21**	**(0.90 to 1.63)**	**0.64**	**(0.53 to 0.77)**
Age-group (vs. 10-15y)										
16-17y	1·40	(1·21 to 1·61)	2·30	(1·63 to 3·25)	1·88	(1·35 to 2·63)	1.13	(0.80 to 1.58)	1.08	(0.87 to 1.35)
18-19y	2·10	(1·82 to 2·42)	4·34	(3·10 to 6·07)	2·76	(1·98 to 3·86)	1.60	(1.13 to 2.26)	1.44	(1.16 to 1.79)
Socio-economic status (vs. least deprived)										
Second least	1·17	(0·89 to 1·54)	0·81	(0·55 to 1·18)	1·13	(0·70 to 1·84)	1·28	(0·80 to 2·04)	1·15	(0·80 to 1·65)
Middle	1·19	(0·92 to 1·56)	0·69	(0·47 to 1·01)	1·29	(0·82 to 2·04)	1·12	(0·70 to 1·79)	1·28	(0·90 to 1·81)
Second most	1·53	(1·20 to 1·95)	0·89	(0·64 to 1·25)	1·44	(0·94 to 2·22)	0·97	(0·61 to 1·55)	1·48	(1·07 to 2·06)
Most deprived	1·57	(1·24 to 1·98)	0·78	(0·57 to 1·08)	1·64	(1·09 to 2·47)	1·02	(0·67 to 1·57)	1·59	(1·17 to 2·16)
Chronic condition (vs. none)	3·77	(3·38 to 4·20)	1·91	(1·54 to 2·36)	2·53	(2·02 to 3·16)	2.35	(1.80 to 3.07)	10.14	(8.29 to 12.41)
Boys										
Adversity- (vs. accident-related) injury	**1·94**	**(1·80 to 2·08)**	**3·15**	**(2·73 to 3·63)**	**3·53**	**(3·04 to 4·09)**	**1·26**	**(1·09 to 1·47)**	**0·99**	**(0·84 to 1·17)**
Age-group (vs. 10-15y)										
16-17y	1·73	(1·58 to 1·89)	2·70	(2·21 to 3·30)	3·05	(2·41 to 3·84)	1·60	(1·35 to 1·89)	1·14	(0·97 to 1·35)
18-19y	2·23	(2·04 to 2·44)	3·48	(2·83 to 4·26)	5·04	(4·03 to 6·31)	1·91	(1·61 to 2·27)	1·22	(1·02 to 1·45)
Socio-economic status (vs. least deprived)										
Second least	1·24	(1·08 to 1·42)	1·17	(0·89 to 1·54)	1·19	(0·86 to 1·63)	1·62	(1·25 to 2·09)	1·14	(0·88 to 1·47)
Middle	1·28	(1·13 to 1·46)	1·19	(0·92 to 1·56)	1·66	(1·24 to 2·22)	1·62	(1·25 to 2·07)	1·02	(0·79 to 1·32)
Second most	1·42	(1·26 to 1·61)	1·53	(1·20 to 1·95)	1·86	(1·41 to 2·45)	1·29	(1·00 to 1·66)	1·33	(1·05 to 1·68)
Most deprived	1·63	(1·45 to 1·83)	1·57	(1·24 to 1·98)	2·17	(1·66 to 2·82)	1·72	(1·36 to 2·18)	1·26	(1·01 to 1·58)

Chronic condition (vs. none)	2·63	(2·45 to 2·82)	1·26	(1·08 to 1·47)	1·81	(1·56 to 2·09)	1·62	(1·39 to 1·88)	11·72	(10·09 to 13·61)

Each column (by sex) represents a separate Fine & Gray's competing risks model. Adversity (vs. accident-related) injury, age-group, socio-economic status, and chronic condition status were entered as covariates simultaneously, per model.
DA = Drug/alcohol-related

Table 3: Relative risk of cause-specific death within 10 years after each type of adversity-related index injury (vs. accident-related injury), adjusted for age-group, socio-economic status, and chronic conditions, by sex (multivariable analyses)

	Cause of death, Sub-hazard ratio (95% Confidence Interval)									
Type of adversity-related index injury (vs. accident-related)	**All deaths**		**Suicide**		**DA death**		**Accidental death**		**Other death**	
Girls										
Self-inflicted	1·52	(1·33 to 1·73)	5·11	(3·61 to 7·23)	5·14	(3·50 to 7·55)	1.17	(0.85 to 1.63)	0.59	(0.48 to 0.72)
Drug/alcohol-related	1·45	(1·28 to 1·64)	4·55	(3·23 to 6·39)	4·52	(3·14 to 6·51)	1.20	(0.88 to 1.64)	0.62	(0.51 to 0.75)
Violent	1·24	(0·93 to 1·66)	1·48	(0·73 to 2·98)	2·75	(1·47 to 5·17)	1.34	(0.71 to 2.55)	0.76	(0.46 to 1.23)
Boys										
Self-inflicted	2·83	(2·58 to 3·10)	6·20	(5·27 to 7·30)	5·91	(4·96 to 7·03)	1.31	(1.05 to 1.64)	1.07	(0.84 to 1.35)
Drug/alcohol-related	2·46	(2·27 to 2·66)	4·51	(3·89 to 5·24)	4·91	(4·24 to 5·73)	1.40	(1.18 to 1.67)	1.11	(0.92 to 1.34)
Violent	1·25	(1·13 to 1·39)	1·43	(1·15 to 1·78)	1·78	(1·44 to 2·19)	1.10	(0.90 to 1.35)	0.76	(0.59 to 0.97)

Each cell represents a separate Fine & Gray's competing risks model, where the corresponding type of adversity-related index injury (vs. accident-related injury), age-group, socio-economic status, and chronic condition status were entered as covariates simultaneously, per model. Sub-hazard ratios for age-group, socio-economic status, and chronic condition status, for each of the thirty models are not presented here but were very similar to those presented in Table 2 (conditional on sex and cause of death).
DA = Drug/alcohol-related

557

Panel: Research in context

Systematic review

We searched for studies (including reviews) of cause-specific death after hospital attendance for any adversity-related injury published from Jan 1995-May 2016. We searched Google Scholar, Scopus, PubMed, and Web of Science using terms ‘’adolescents’’, ‘’injury’’, ‘’hospital’’, ‘’self-harm’’, ‘’drug or alcohol use’’, ‘’violence’’, and ‘’mortality’’. We found six studies (seven articles), but no relevant systematic review. Five (European) studies reported risks of death due to suicide, and some also reported risks of deaths due to drug/alcohol use (n=2), homicide (n=2), undetermined/accidental causes (n=3), and chronic conditions (n=3), in up to 15 years after adolescents presented to hospital with self-inflicted injury. One (US) study reported frequencies of deaths from homicide, drug overdose, and traffic accidents in the two years after discharge following violent injury in 559 adolescents. We did not identify any studies that reported rates of cause-specific death following hospital presentation or admission for drug/alcohol-related injury, or compared risks of cause-specific deaths after discharge following any adversity-related injury with those following accident-related injury.

Interpretation

Our study adds new evidence on the risks of cause-specific death up to ten years after discharge following adversity-related and accident-related injury among young people. Our finding of elevated risks of suicide following all types of adversity-related injury (versus accident-related injury) suggests that clinical and public health strategies need to be extended to reduce harm after all types of adversity-related injury, whether self-inflicted, drug/alcohol-related or violent. Similar risks of suicide and drug/alcohol-related deaths following discharge from any type of index injury found in our study also stress the need of preventive strategies, both within and outside the healthcare sector, to reduce public health burden of suicide and drug/alcohol-related deaths.