

Identification of incident poisoning, fracture and burn events using linked primary care, secondary care, and mortality data from England; implications for research and surveillance

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Key words: wounds and injury, epidemiology, child, adolescent

ABSTRACT

Background

English national injury data collection systems are restricted to hospitalisations and deaths. With recent linkage of a large primary care database, the Clinical Practice Research Datalink (CPRD), with secondary care and mortality data we aimed to assess the utility of linked data for injury research and surveillance by examining recording patterns and comparing incidence of common injuries across data sources.

Methods

The incidence of poisonings, fractures and burns was estimated for a cohort of 2,147,853 0-24 year olds using CPRD linked to Hospital Episode Statistics (HES) and Office for National Statistics (ONS) mortality data between 1997-2012. Time-based algorithms were developed to identify incident events, distinguishing between repeat follow-up records for the same injury, and those for a new event.

Results

We identified 42,985 poisoning, 185,517 fracture and 36,719 burn events in linked CPRD-HES-ONS data; incidence rates were 41.9 per 10,000 person-years (95% confidence interval 41.4–42.4), 180.8 (179.8–181.7) and 35.8 (35.4–36.1), respectively. Of the injuries, 22,628(53%) poisonings, 139,662(75%) fractures, and 33,462(91%) burns were only recorded within CPRD. Only 16% of deaths from poisoning ($n=106$) or fracture ($n=58$) recorded in ONS were recorded within CPRD and/or HES records. None of the 10 deaths from burns were recorded in CPRD or HES records.

Conclusion

It is essential to use linked primary care, hospitalisation and deaths data to estimate injury burden, as many injury events are only captured within a single data source. Linked routinely-collected data

offer an immediate and affordable mechanism for injury surveillance and analyses of population-based injury epidemiology in England.

BACKGROUND

Injuries remain an important preventable cause of morbidity, hospitalisation and health inequality among children and young people in England.(1-4) Understanding the burden of injuries is important for health service planning and the prioritisation of preventative interventions to those at greatest risk. Despite this, estimating injury burden in England remains a challenge due to fragmented data collection systems and no national surveillance system. Most existing injury studies have relied on single data sources,(5-7) such as emergency department (ED) or hospitalisation data, and so underestimate injury burden as injuries seen in primary care or minor injury units are not captured. With recent linkage of a primary care research database to hospitalisation and mortality data, there is new potential to build a more complete picture of the epidemiology of injuries in England. We aimed to estimate population incidence figures for three common childhood injuries (poisonings, fractures, burns) through developing methods to define incident injury events across linked data. We focused on poisonings, fractures and burns as they are three of the commonest injuries of childhood and adolescence,(8, 9) and have been highlighted as priorities for prevention among under 5s in England.(1) We also describe the recording of injury mechanisms and intent according to data source, in order to assess the utility of these data for injury surveillance and future studies of injury burden and prevention.

METHODS

Data sources

We used three routinely-collected data sources from England: the Clinical Practice Research Datalink(CPRD), Hospital Episode Statistics(HES) and Office for National Statistics(ONS) mortality data. The CPRD is a longitudinal primary care research database containing the anonymised demographic, medical, prescription and lifestyle data of over 15 million patients from the United Kingdom (UK).(10) Within the UK, healthcare is available free at the point of access via the National Health Service (NHS), with about 98% of the population registered with a general practitioner

(GP).(11) Diagnostic and lifestyle information are recorded in the electronic primary care record using Read codes,(12) with information received from secondary and tertiary care (e.g. ED attendances, hospitalisations, and specialist unit admissions) also coded in the medical record. Previous studies have shown high levels of transcription of diagnostic information from hospital discharge records and outpatient clinic letters into the electronic record;(13, 14) although the completeness of injury recording is unknown. CPRD undergoes quality checks to ensure only high quality data are used for research.

The HES dataset contains details of all emergency and elective inpatient admissions (of any duration) to NHS hospitals in England, including care paid for by the NHS but delivered by independent or private treatment centres. Diagnoses and procedures are coded using the International Classification of Diseases 10th revision (ICD-10) and the Office of Population Census and Surveys version 4 (OPCS-4) respectively. The ONS mortality dataset contains the date and cause of death (coded using ICD-10) for all deaths registered in England.

Linkage of data sources

Linkage of CPRD, HES and ONS mortality data was carried out by a trusted third party prior to anonymisation using the patient's NHS number, gender and date of birth. Linkage is currently available for 375 (55%) of the general practices submitting data to CPRD; representing about 5% of general practices in England. While general practices participate in CPRD on a voluntary basis, a previous comparison of the CPRD-HES linked practices to demographic data for the UK has shown broadly similar age and sex structures.(15) Infants, young adults and practices from the North East, East Midlands and Yorkshire are slightly underrepresented within CPRD-HES linked data;(15) likely to relate to delayed GP registration of infants after birth, changes in life circumstances among young adults (e.g. moving home, going to university), and regional variation in the uptake of the Vision clinical software system required for participation in the CPRD.

Study population

Using these data sources, we carried out an open cohort study of children and young people aged 0-24 years old who were registered at general practices participating in the CPRD between the 1st of April 1997 and the 31st of March 2012, who also had linked HES and ONS mortality data. For each subject, the entry date to the study was the most recent date of: their date of birth, practice registration date, the date the practice met CPRD data quality standards, or the date from which linked HES data were available (1st April 1997). Patients left the cohort at the earliest date of: the 31st March 2012, when the child/young person died, reached the age of 25, changed general practice or when the practice stopped participating in CPRD. When a patient changed general practice follow-up ceased, as patients do not retain their unique identifiers within the database.

Defining injury outcomes

We extracted all injury records for poisonings, fractures and burns using a comprehensive Read code list for CPRD, and ICD-10 code lists for HES and ONS mortality data. In addition, treatment procedures (e.g. fixation of fracture) were extracted from HES using an OPCS-4 code list. As the primary cause of injury death is recorded in England using external cause codes (ICD-10 V01-Y98), we examined all causes of death recorded per child to identify fracture, poisoning or burn events. For example, the primary cause of death could be a transport accident, but the death would be classified as a fracture case if a child had sustained multiple fractures.

Defining incident events

We aimed to identify all incident poisoning, fracture and burn events per child, distinguishing between records for follow-up care, and those indicating new events. We counted injury events, as opposed to individually injured sites, such that if a child sustained multiple injuries of the same type (e.g. multiple fractures at different sites), this was only counted once.

We firstly excluded codes referring to complications and past injuries. Secondly, we used an algorithm, consisting of a series of time-windows, to distinguish between repeat codes for the same event and those for a new event (Table 1). Subsequent hospitalisations and primary care codes occurring within the relevant time-window after the first code were considered part of the same injury event. We used a longer time-window for injury events where the first record was a hospitalisation, as injuries requiring admission may be more severe and require longer follow-up. A third time-window determined whether hospitalisations occurring after the event start date referred to the same (e.g. readmission) or a new event. For burns, an additional time-window of 2 years was used to account for the small number of children who sustain severe burns requiring multiple grafts. The algorithm thus accounted for simple injury management such as one visit to a GP and complex management involving GP and hospital follow-up. For example, for a child initially admitted to hospital with a fracture, any CPRD records occurring within 26 weeks of this admission were considered the same event. A CPRD record occurring after 26 weeks of this event date was considered a new event. Further detail is given in Supplementary file 1.

We defined time-windows for each injury type by plotting the rates of relevant injury codes entered in CPRD or HES after the first injury code (Supplementary file 1). The point at which the rate plateaued was used to define the end of the time-window during which all injury-related codes related to the first code. Clinical plausibility was also taken into account; for example, relatively short time-windows were chosen for poisonings, as repeat self-poisonings commonly occur within two to three months of the initial event,⁽¹⁶⁾ and poisoning hospitalisations are most likely to be incident events.⁽¹⁷⁾

Table 1: Description of time-windows used to identify incident poisoning, fracture and burn events

Description of time-window	Rationale for time-window	Poisonings (weeks)	Fractures (weeks)	Burns (weeks)
Time-window 1: From first to subsequent code in CPRD. Time from the start date of injury event, i.e. when the first code for the injury event was recorded in primary care (CPRD). Codes recorded in primary care within this time-window were considered the same injury event.	Time-window used to exclude codes likely to be follow-up care recorded in primary care.	3	26	3
Time-window 2: From first code in HES to subsequent code in CPRD. Time from the hospital discharge date. Used in cases where the first code of the injury event was a hospital admission recorded in HES. Codes recorded in primary care within this time-window were considered the same injury event.	An injury leading to hospital admission may be more severe, and require longer follow-up after discharge. Time from discharge used to account for injuries requiring prolonged hospital admission.	4	26	8
Time-window 3: From first CPRD or HES record to subsequent code in HES. <ul style="list-style-type: none"> • Time from the start date of injury event if first code recorded in CPRD OR <ul style="list-style-type: none"> • Time from the hospital discharge date if first code recorded in HES. <p>After this time-window, a hospital admission would be considered a new injury event.</p>	Time-window used to distinguish whether a subsequent hospital admission could indicate the same (e.g. hospital transfer, readmission) or a new injury event.	1	12	6
Time-window 4 (burns only): From first CPRD or HES record to procedural codes for skin grafts. Time from the start date of injury event (whether recorded in CPRD or HES) to codes for skin grafts recorded in CPRD or HES.	Time-window used for burns to account for a small number of children with prolonged follow-up and multiple graft procedures following a severe burn.	-	-	104

Defining mechanism and intent of injury

Understanding how an injury occurred (the mechanism e.g. fall) and whether an injury was intentional or unintentional (the intent) is important when identifying and implementing prevention strategies.⁽¹⁸⁾ For each hospitalisation and death, ICD-10 codes V01-Y36, Y90-Y98 were extracted to assess the proportion of events with a documented mechanism and intent, classifying intent as unintentional, intentional, or undetermined. For events recorded in CPRD, we extracted relevant Read codes (mapped to ICD-10 V01-Y36, Y90-Y98) for those who had sustained a poisoning, fracture or burn. We assessed the proportion of injury events where a code referring to a mechanism or intent had been recorded on the same day as a code for that injury type.

Statistical analyses

For each data source separately and in linked CPRD-HES-ONS data we counted the number of incident injury events, as indicated by the first primary care, hospitalisation or death record within the relevant time-window(s) (Table 1). We identified the proportion of events recorded in both CPRD and HES, and those captured by all three data sources, by identifying those events with records from more than one data source within the relevant time-window.

Incidence rates of poisoning, fracture and burn events overall and by age were estimated per 10,000 person-years (PY), with 95% confidence intervals (95%CI), using CPRD, HES, ONS mortality data and the three data sources together (CPRD-HES-ONS). We assessed the proportion of injury events with a mechanism and intent recorded, and conducted a sensitivity analysis to assess the impact of doubling the time-windows used to define incident injury events (e.g. a time-window of 3 weeks was extended to 6 weeks in the sensitivity analysis). All data management was conducted using Stata version 13.0.

Ethical approval

This study was approved by the Independent Scientific Advisory Committee for the Medicines and Healthcare products Regulatory Agency (protocol 13-199).

RESULTS

For the study period 1997-2012, there were 2,147,853 children and young people aged 0-24 within the CPRD database who had linked HES and ONS mortality data and were eligible for inclusion in the study. Of the study cohort 1,049,150 (49%) were male and 1,098,703 (51%) were female (Table 2). Similar proportions of the population were from each socioeconomic quintile, with some underrepresentation of quintiles 3 (18.6%) and 5 (19.1%). A high proportion (35.0%) of the study cohort had missing ethnicity data. Those from White (55.9%) and Asian (3.6%) ethnic groups were underrepresented compared to the 2011 Census (86% and 7.5% respectively);(19) with the missing group likely to largely represent those of White ethnicity. The regions of England contributing the highest proportions of subjects were the North West (15.8%) and London (15.5%). Median follow-up was 3.2 years (interquartile range 1.3-7.5).

Table 2: Characteristics of 0-24 year old children and young people within the linked CPRD-HES-ONS databases during the study period 1997-2012

	Frequency	Percentage %
Sex		
Male	1,049,150	48.8
Female	1,098,703	51.2
Age at start of follow up (years)		
0-4	777,546	36.2
5-9	301,562	14.0
10-14	262,621	12.2
15-19	309,479	14.4
20-24	496,645	23.1
Household socioeconomic quintile (IMD 2010)^B		
1 (least deprived)	447,834	20.9
2	429,876	20.0
3	399,410	18.6
4	436,918	20.3
5 (most deprived)	410,603	19.1
Missing	23,212	1.1
Ethnicity*		
White	1,199,626	55.9
Mixed	31,449	1.5
Indian	28,355	1.3
Pakistani	20,628	1
Bangladeshi	6,294	0.3
Any other Asian background	21,358	1
Black Caribbean	10,500	0.5
Black African	31,409	1.5
Any other Black background	14,462	0.7
Chinese	7,856	0.4
Any other ethnic group	24,617	1.1
Missing or unknown	751,299	35.0
Region where general practice located		
North East	41,135	1.9
North West	339,089	15.8
Yorkshire and Humber	93,187	4.3
East Midlands	76,830	3.6
West Midlands	247,618	11.5
East of England	251,698	11.7
South West	242,240	11.3
South Central	261,411	12.2
London	333,786	15.5
South East Coast	260,859	12.1

*As recorded in HES and/or CPRD

^B The Index of Multiple Deprivation (IMD) 2010 is an area based measure of relative deprivation used in England, based upon 38 indicators covering income, employment, health, education, crime, access to services and the living environment.

Injury events according to data source

Over the study period we identified 42,985 poisoning, 185,517 fracture and 36,719 burn events for the population in linked CPRD-HES-ONS data (Table 3). This compared to 34,091, 169,491 and 35,049 events respectively when using CPRD alone. A total of 106 children were identified in ONS mortality data with a recorded cause of death from poisoning, 58 from fracture and 10 from burns. Among those who died, most were aged 15-24 (97.3% of poisonings, 88% of fractures and 70% of burns).

When using linked CPRD-HES-ONS data, the proportions of events identified in each data source varied by injury type (Figure 1). For poisonings, 52.6% of events were only identified using CPRD, as were 75.3% of fracture and 91.1% of burn events. Compared to using CPRD alone, the addition of HES data increased the ascertainment of injury events for each injury type, with the greatest relative impact for poisonings. Of the children who died with one of these injury types, 17 (16.0%) poisonings and 9 (15.5%) fractures were identified in CPRD and/or HES. None of the 10 children who died from burns were identified in CPRD and/or HES when using our code lists.

Table 3: Injury incidence according to data source in 0-24 year old children and young people

Data Source	Poisonings			Fractures			Burns		
	Number of poisoning records in data source(s)	Number of incident events	Rate per 10,000 PY (95% CI)	Number of fracture records in data source(s)	Number of incident events	Rate per 10,000 PY (95% CI)	Number of burn records in data source(s)	Number of incident events	Rate per 10,000 PY (95% CI)
Clinical Practice Research Datalink (CPRD) *	37,855	34,091	33.2 (32.8, 33.6)	231,024	169,491	165.1 (164.3, 166.0)	42,978	35,049	34.1 (33.8, 34.5)
Hospital Episode Statistics (HES) ^β	20,724	20,259	19.7 (19.5, 20.0)	48,902	45,803	44.6 (44.2, 45.1)	3,673	3,247	3.2 (3.1, 3.3)
Office for National Statistics (ONS) mortality data [#]	106	106	0.1 (0.09, 0.12)	58	58	0.06 (0.04, 0.07)	10	10	0.01 (0.005, 0.02)
Linked CPRD-HES-ONS data	58,685 ^a	42,985	41.9 (41.4, 42.4)	279,984	185,517	180.8 (179.8, 181.7)	46,661	36,719	35.8 (35.4, 36.1)

* CPRD captures injuries seen in primary care, and information received from secondary and tertiary care (e.g. minor injury unit and ED attendances, hospital admissions).

^β HES captures inpatient hospital admissions.

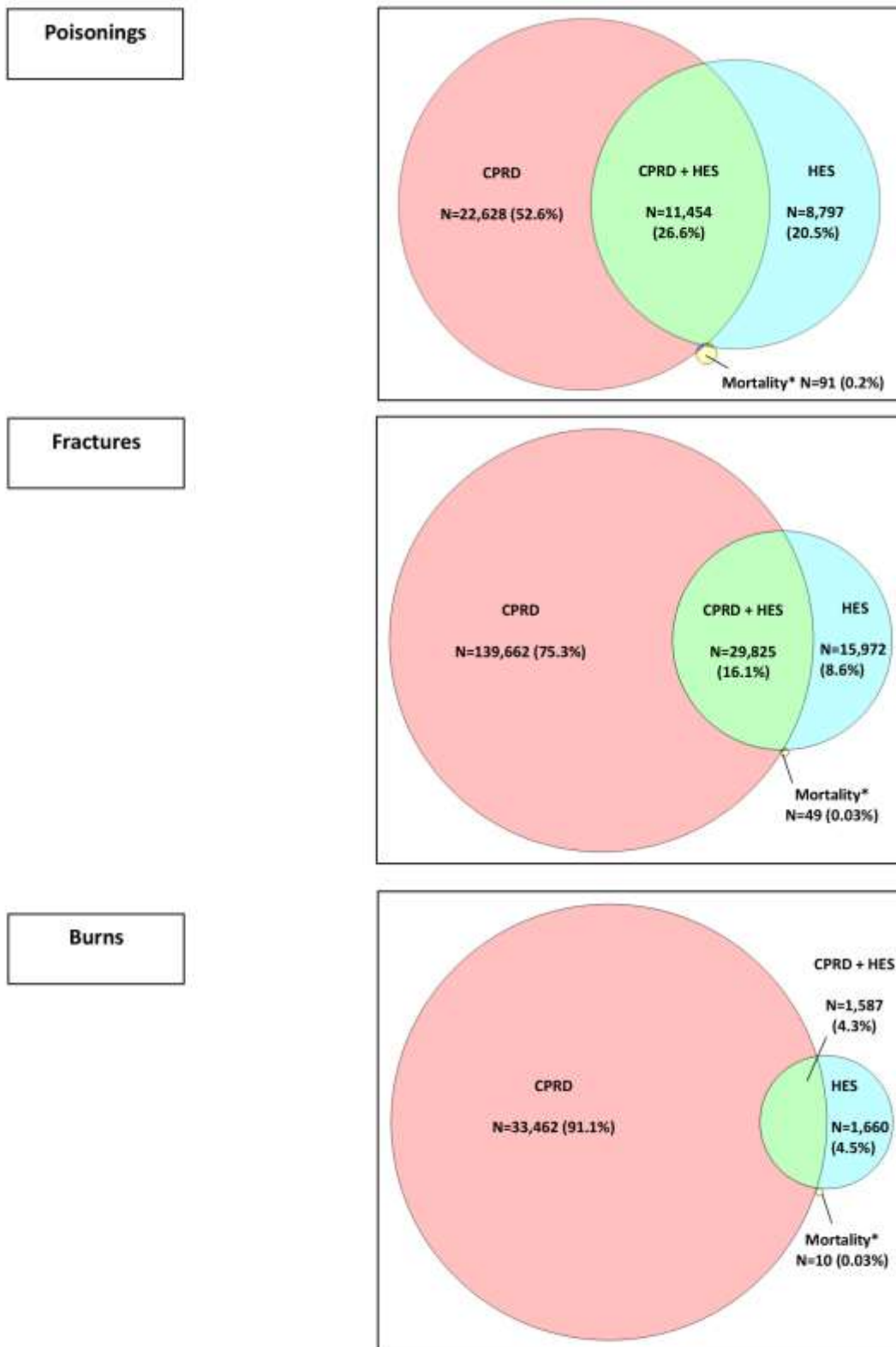
[#] ONS mortality data captures those with an injury recorded as a cause of death on their death certificate.

^a The number of records in linked CPRD-HES-ONS mortality data is the sum of the records identified in each data source separately.

PY: person-years

95% CI: 95% confidence intervals

Figure 1: Numbers and percentages of poisoning, fracture and burn events identified in primary care (Clinical Practice Research Datalink (CPRD)), secondary care (Hospital Episode Statistics (HES)) and deaths (Office for National Statistics mortality) data.



*Numbers of children who died from a poisoning, fracture or burn, where this information was also recorded within CPRD, HES or both CPRD and HES, have not been shown in these diagrams due to the ethical constraint of reporting the small numbers involved.

Incidence according to data source

Overall incidence rates for the study period were 41.9/10,000PY (95%CI 41.4, 42.4) for poisonings, 180.8 (95%CI 179.8, 181.7) for fractures, and 35.8 (95%CI 35.4, 36.1) for burns in linked CPRD-HES-ONS data (Table 3). For each injury type, estimated incidence was higher in linked CPRD-HES-ONS data than when using CPRD alone (non-overlapping 95% CI), with rates 26%, 10% and 5% higher for poisonings, fractures and burns, respectively. Figure 2 shows incidence rates for the three injury types by data source and child age. Poisoning incidence peaked at age 2 and again at 18 years old; compared to single peaks in incidence for fractures and burns at 13 and 1 years old, respectively.

Sensitivity analysis: extending time-windows to define events

We identified 42,214 poisoning, 180,202 fracture and 36,425 burn events in the sensitivity analysis; 98%, 97% and 99%, respectively of the events identified in the primary analysis. Confidence intervals overlapped between incidence rates by injury type and child age in the primary and sensitivity analyses (Supplementary file 2). Proportions of events identified in CPRD alone, HES alone, and in both data sources did not vary from the primary analyses.

Recording of injury mechanism and intent

Injury mechanism was recorded in a small percentage of CPRD injuries: 2,650 (2%) of fracture and 1,417 (4%) of burn events, but was more complete in HES: 40,924 (89%) and 2,592 (80%) respectively (Table 4). In linked data, an injury mechanism and intent were identified for 23% of fractures ($n=41,770$) and 11% of burns ($n=3,885$). For those with a mechanism recorded, the leading mechanisms were falls (50%) and transport incidents (18%) for fractures, and heat/hot substances (66%) and smoke/fire/flames (17%) for burns. Intent was well recorded across all data sources for poisonings; identified for 34,870(81%) of events in linked data. Of these events, 22,588 (53%) were recorded as intentional, 11,737(26%) as unintentional, and 538 (1%) as undetermined intent.

Figure 2: Crude incidence of poisonings, fractures and burns according to age, using linked primary care, secondary care and mortality data (1997–2012).

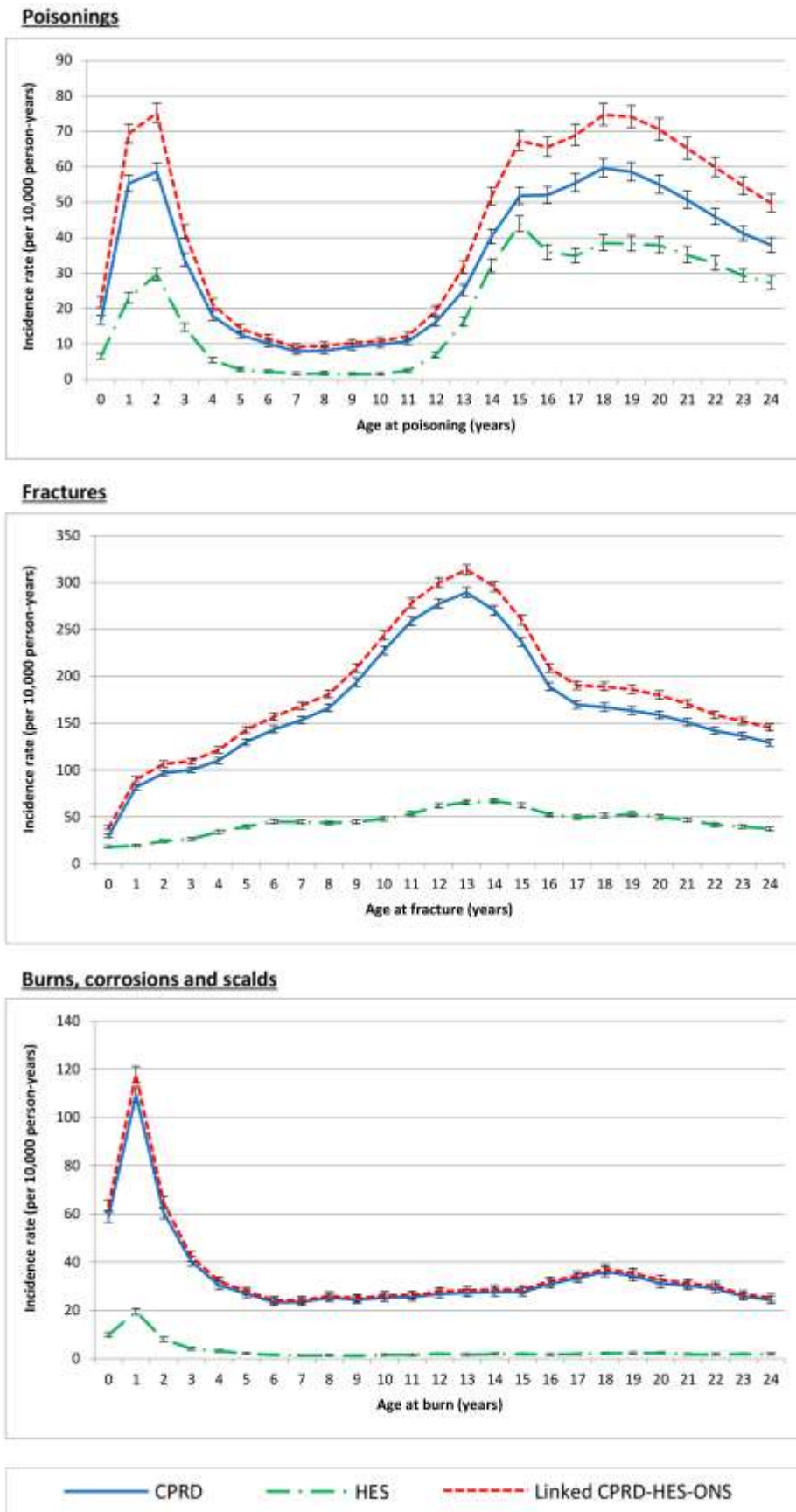


Table 4: Recording of injury mechanism and intent according to data source in 0-24 year olds

		Primary care data, CPRD [*] Number (%)	Hospital admissions data, HES [#] Number (%)	Mortality data, ONS [#] Number (%)	Linked CPRD-HES-ONS Number (%)
Poisonings (n=42,985)	Mechanism ^β	-	-	-	-
	Intent	25,958 (76)	19,707 (97)	106 (100)	34,870 (81)
Fractures (n=185,517)	Mechanism	2,650 (2)	40,924 (89)	58 (100)	41,770 (23)
	Intent	2,672 (2)	40,919 (89)	58 (100)	41,792 (23)
Burns, scalds and corrosions (n=36,719)	Mechanism	1,417 (4)	2,592 (80)	10 (100)	3,885 (11)
	Intent	1,421 (4)	2,592 (80)	10 (100)	3,889 (11)

^{*} Intent and mechanism defined in CPRD using Read codes corresponding to ICD-10 V01-Y36, Y90-Y98.

[#] Intent and mechanism defined in HES and ONS mortality data using ICD-10 codes V01-Y36, Y90-Y98.

^β As poisonings are both a mechanism and injury type, mechanism recording has not been reported here.

DISCUSSION

We report the first UK study to estimate injury incidence using linked primary care, hospitalisation and mortality data, with methods developed to define incident events across these linked data. We have demonstrated that it is essential to use multiple data sources to provide more complete estimates of injury incidence, as many injury events are only captured within a single data source. For example, only 1 in 6 deaths from poisonings and fractures were captured by primary and/or secondary care data.

Strengths and limitations

The main strengths of our study are the large study size and use of linked prospectively recorded data to identify events. By defining incident events within linked data, we were able to include multiple events per child over time; an issue of importance in estimating injury burden and for surveillance. In addition, with universal healthcare coverage, and emergency care almost exclusively delivered by the NHS,(20) we are unlikely to have substantially underestimated injury incidence as a result of injuries being seen within the private medical sector.

Linked CPRD-HES-ONS data are broadly representative of the UK population,(15) and remain the most complete and accurate method currently available in England to estimate injury incidence.

While there is some underrepresentation of certain groups within linked CPRD-HES data,⁽¹⁵⁾ it is reassuring that our study cohort is evenly distributed by socioeconomic status (between 18.9-20.9% in each quintile), an important factor affecting injury incidence. Underrepresentation of young adults, and those from the North East, East Midlands and Yorkshire could lead to some underestimation of injury incidence, as rates tend to be higher in these groups.^(9, 21) Ongoing recruitment of practices to CPRD, and plans for future widespread access to primary care data across the UK⁽²²⁾ should increase population and geographical coverage.

By using a time-based algorithm, we may have erroneously treated an injury code as a continuation of the same event, or conversely treated a code as a new event. We however demonstrated in our sensitivity analysis that even when these time-windows were doubled, incidence by child age was similar to the primary analysis for all injury types.

Within the UK standardised national ED data are still in development with provisional data sets incomplete and of varying quality.⁽²³⁾ The lack of ED data linked to CPRD-HES-ONS means it is likely we have not identified all injury events, including those recorded in CPRD using non-specific codes (e.g. seen in ED) or within the free text of the medical record. Quantifying the number of ED attendances not captured within CPRD is a challenge. Until 2002, the Home and Leisure Accident Surveillance System (HASS/LASS) captured injury occurrences from a sample of 16-18 UK EDs. For fractures, an injury where a high proportion of the burden is captured in ED data, HASS/LASS estimated incidence as 221/10,000 for the time-period 1997-2002, which compares to our estimate of 155/10,000 for this period; indicating we may be underestimating fracture incidence by about 40%. Comparisons for poisonings and burns are more complex due to differences in definitions, and the proportion of the injury burden captured in ED data (Supplementary file 3). While it is likely we are underestimating incidence, there is little evidence to suggest that GPs differentially record injury occurrences (e.g. by age, sex, region) and our results still provide vital information on the trends and patterns of different injury types.

Quantifying the severity of injuries, and the number of children sustaining multiple injuries within the same event (e.g. multiple fractures) is complex in CPRD, due to, for example the use of non-specific codes (e.g. 43% of the fracture Read codes used did not specify an anatomical site) and potential selective recording of the most severe injuries by GPs. As injury severity, and the number of injury types and body regions injured affect functional and health status outcomes,(24) quantifying this injury burden is important. Future studies using linked data will need to develop methods to systematically identify children sustaining multiple injuries, and assess the feasibility of defining injury severity within these data.

Read codes specifying a mechanism and/or intent were infrequently used within CPRD for the injury types we assessed. Further information may be recorded within the free text of the record or coded in alternative ways (e.g. in suspected intentional injury a code such as 'referral to social services' may be used,(25) without an injury code). For these reasons, we may have underestimated the recording of mechanisms and intent in primary care data; although our finding does reflect data that can be routinely extracted from CPRD, and that corresponds to the ICD-10 external cause codes.

Comparison with previous studies

Our estimate of fracture incidence (180.8/10,000PY) and observed patterns according to age, are consistent with other UK studies;(9, 26, 27) although lower than HASS/LASS. Rennie *et al* used a hospital-based database, estimating fracture incidence as 202/10,000 for 0-16 year olds living in Edinburgh.(26) In this study, 1.2% of children sustained multiple fractures, with each fracture included separately, which in part explains our lower incidence of 192/10,000 for this age group. Similarly, Lyons *et al* used a Welsh database of ED attendances, giving an incidence of 361/10,000 for 0-14 year olds.(27) This compares to our estimate of 187/10,000 for children of this age, which may in part be explained by regional variation in fracture incidence between Wales and England.(9)

For poisonings, the majority of UK studies come from individual hospital sites, focusing on hospitalisation or ED rates.(28, 29) We found poisoning incidence peaked at ages 2 and 18 years, likely to reflect the different aetiologies of poisoning in preschool children compared to young people (unintentional versus intentional).(30) A study using ED data from the USA estimated poisoning incidence for children aged 0-4 as 42.9/10,000; consistent with our estimate of 46.3/10,000 for this age group.(31) In addition, rates from a US surveillance system for 10-19 year olds were 61.8/10,000,(32) which compares to 46.8/10,000 for this age group in our study.

Most UK studies of burns incidence focus on those requiring admission or specialist burns care, giving rates considerably lower than our estimates.(33-36) A study using a surveillance system in Massachusetts, gave an estimated burns incidence of 50/10,000 for 0-19 year olds;(37) broadly consistent with our estimate when taking account of changes in burns incidence over time(33) and that we may not have captured all burns ED attendances.

Implications for research and practice

We have demonstrated that it is essential to use linked data sources to build a more complete picture of injury burden, indicating that future injury studies using primary care research databases should use linked hospitalisation and mortality data. While there have been plans to establish injury surveillance and reporting systems across Europe using a standardised ED dataset, these systems, and the funding to implement them are yet to be in place in the UK.(38) Current reliance on hospitalisation and mortality data means that much of the injury burden within England is not accounted for within health service or injury prevention planning. While injuries not requiring admission may be less severe, many still have a significant impact in terms of time off work or school, costs of follow-up care, and psychological impact.(39) With it now being feasible to link routinely collected primary care, hospitalisation and mortality data, these data offer an immediate and affordable mechanism for injury surveillance in England. In addition these data offer an inexpensive and efficient mechanism of obtaining outcome data for evaluations of injury prevention

interventions. As linked ED data become available in the future, this will increase both the completeness of injury events captured, and information about injury mechanism and intent. Recording of injury mechanisms in primary care could be improved by providing guidance on injury recording and simplified mechanism and intent categories (e.g. similar to ED minimum datasets).(40) Future research should include the linking of ED data to CPRD-HES-ONS data, extending this work to cover all injury types, and the development of methods to define those sustaining multiple injuries.

What is already known on this subject

- Current injury data sources based on hospital admissions and deaths underestimate injury burden, though the extent of this underestimation unknown.
- Large primary care databases have been used for injury epidemiology, taking advantage of the longitudinal medical record maintained over a patient's life.
- The extent that injuries seen in secondary care are accurately recorded within primary care data is unknown.

What this study adds

- Using primary care, secondary care or mortality data in isolation, misses a substantial proportion of injury events.
- Future injury studies using large primary care databases should use linked hospital admission and mortality data.
- Linked data holds potential for injury surveillance, particularly with plans for widespread access to primary care data in England.

Competing Interests: We declare that we have no competing interests.

Authors' Contributions: All authors were involved in the conception and design of the study. RB undertook the analysis and drafted the manuscript. All authors contributed to interpreting the findings and revising the manuscript.

Funding: RB is funded by the National Institute for Health Research (NIHR) School for Primary Care Research (SPCR) and The University of Nottingham. The views expressed are those of the authors and not necessarily those of the NHS, the NIHR or the Department of Health.

Ethics statement: Approval for this study was obtained from the Independent Scientific Advisory Committee for the Medicines and Healthcare products Regulatory Agency in December 2013.

REFERENCES

1. Public Health England. Reducing unintentional injuries in and around the home among children under five years. London: Public Health England, 2014.
2. Public Health England. Reducing unintentional injuries on the roads among children and young people under 25 years. London: Public Health England, 2014.
3. Audit Commission. Better safe than sorry. Preventing unintentional injury to children. London: Audit Commission; 2007.
4. Orton E, Kendrick D, West J, et al. Persistence of Health Inequalities in Childhood Injury in the UK; A Population-Based Cohort Study of Children under 5. *PLoS One*. 2014;9(10):e111631.
5. Hardeid P, Davey J, Dattani N, et al. Child deaths due to injury in the four UK countries: a time trends study from 1980 to 2010. *PLoS One*. 2013;8(7):e68323.
6. MacInnes K, Stone DH. Stages of development and injury: an epidemiological survey of young children presenting to an emergency department. *BMC Public Health*. 2008;8:120.
7. Lyons RA, Lo SV, Heaven M, et al. Injury surveillance in children--usefulness of a centralised database of accident and emergency attendances. *Inj Prev*. 1995;1(3):173-6.
8. Agran PF, Winn D, Anderson C, et al. Rates of pediatric and adolescent injuries by year of age. *Pediatrics*. 2001;108(3):E45.
9. Cooper C, Dennison EM, Leufkens HG, et al. Epidemiology of childhood fractures in Britain: a study using the general practice research database. *J Bone Miner Res*. 2004;19(12):1976-81.
10. Clinical Practice Research Datalink. CPRD 2014 [Accessed October 2013]. Available from: <http://www.cprd.com/>.
11. Health and Social Care Information Centre. Attribution Data Set GP-Registered Populations 2010. 2012.
12. Benson T. The history of the Read Codes: the inaugural James Read Memorial Lecture 2011. *Informatics in primary care*. 2011;19(3):173-82.
13. Jick H, Jick SS, Derby LE. Validation of information recorded on general practitioner based computerised data resource in the United Kingdom. *BMJ*. 1991;302(6779):766-8.
14. Khan NF, Harrison SE, Rose PW. Validity of diagnostic coding within the General Practice Research Database: a systematic review. *The British journal of general practice : the journal of the Royal College of General Practitioners*. 2010;60(572):e128-36.
15. Crooks C. The epidemiology of upper gastrointestinal bleeding: University of Nottingham; 2013.
16. Kessel N, McCulloch W. Repeated acts of self-poisoning and self-injury. *Proc R Soc Med*. 1966;59(2):89-92.
17. Gedeberg R, Engquist H, Berglund L, et al. Identification of incident injuries in hospital discharge registers. *Epidemiology*. 2008;19(6):860-7.
18. Runyan CW. Introduction: back to the future--revisiting Haddon's conceptualization of injury epidemiology and prevention. *Epidemiol Rev*. 2003;25:60-4.
19. Office for National Statistics. Ethnicity and National Identity in England and Wales 2011. 2012.
20. Institute for Fiscal Studies, Nuffield Trust. Understanding competition and choice in the NHS. Public payment and private provision. The changing landscape of health care in the 2000s. 2013.
21. Public Health England. Public Health Outcomes Framework 2012. Available from: <http://www.phoutcomes.info/>.
22. NHS England. The care.data programme – collecting information for the health of the nation 2014 [Accessed December 2014]. Available from: <http://www.england.nhs.uk/ourwork/tsd/care-data/>.
23. Health and Social Care Information Centre. Hospital Episode Statistics. Accident and Emergency Attendances in England- 2012-2013. 2014.

24. Gabbe BJ, Simpson PM, Lyons RA, et al. Association between the Number of Injuries Sustained and 12-Month Disability Outcomes: Evidence from the Injury-VIBES Study PLoS One. 2014;9(12): e113467.
25. Woodman J, Freemantle N, Allister J, et al. Variation in recorded child maltreatment concerns in UK primary care records: a cohort study using The Health Improvement Network (THIN) database. PLoS One. 2012;7(11):e49808.
26. Rennie L, Court-Brown CM, Mok JY, et al. The epidemiology of fractures in children. Injury. 2007;38(8):913-22.
27. Lyons RA, Delahunty AM, Kraus D, et al. Children's fractures: a population based study. Inj Prev. 1999;5(2):129-32.
28. Camidge DR, Wood RJ, Bateman DN. The epidemiology of self-poisoning in the UK. Br J Clin Pharmacol. 2003;56(6):613-9.
29. Prescott K, Stratton R, Freyer A, et al. Detailed analyses of self-poisoning episodes presenting to a large regional teaching hospital in the UK. Br J Clin Pharmacol. 2009;68(2):260-8.
30. Greene SL, Dargan PI, Jones AL. Acute poisoning: understanding 90% of cases in a nutshell. Postgrad Med J. 2005;81(954):204-16.
31. Franklin RL, Rodgers GB. Unintentional child poisonings treated in United States hospital emergency departments: national estimates of incident cases, population-based poisoning rates, and product involvement. Pediatrics. 2008;122(6):1244-51.
32. Cheng TL, Wright JL, Pearson-Fields AS, et al. The spectrum of intoxication and poisonings among adolescents: surveillance in an urban population. Inj Prev. 2006;12(2):129-32.
33. Brusselaers N, Monstrey S, Vogelaers D, et al. Severe burn injury in Europe: a systematic review of the incidence, etiology, morbidity, and mortality. Critical care (London, England). 2010;14(5):R188.
34. Wilkinson E. The epidemiology of burns in secondary care, in a population of 2.6 million people. Burns. 1998;24(2):139-43.
35. Rajpura A. The epidemiology of burns and smoke inhalation in secondary care: a population-based study covering Lancashire and South Cumbria. Burns. 2002;28(2):121-30.
36. Yeoh C, Nixon JW, Dickson W, et al. Patterns of scald injuries. Arch Dis Child. 1994;71(2):156-8.
37. Gallagher SS, Finison K, Guyer B, et al. The incidence of injuries among 87,000 Massachusetts children and adolescents: results of the 1980-81 Statewide Childhood Injury Prevention Program Surveillance System. Am J Public Health. 1984;74(12):1340-7.
38. Kirkwood G, Hughes TC, Pollock AM. Injury surveillance in Europe and the UK. BMJ. 2014;349:g5337.
39. Heptinstall E. Healing the hidden hurt: the emotional effects of children's accidents. London: Child Accident Prevention Trust, 1996.
40. College of Emergency Medicine. Emergency Care Minimum Dataset v 4.1. 2014.