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SHORT REPORT

Long term health outcomes after injury in working age adults: a systematic review

C M Cameron, E V Kliewer, D M Purdie, R J McClure

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Background: Estimating the contribution of non-fatal injury outcomes remains a considerable challenge and is one of the most difficult components of burden of disease analysis. The aim of this systematic review was to quantify the effect of being injured compared with not being injured on morbidity and health service use (HSU) in working age adults.

Methods: Studies were selected that were population based, had long term health outcomes measured, included a non-injured comparison group, and related to working age adults. Meta-analysis was not attempted because of the heterogeneity between studies.

Results: Nine studies met the inclusion criteria. In general, studies found an overall positive association between injury and increased HSU, exceeding that of the general population, which in some studies persisted for up to 50 years after injury. Disease outcome studies after injury were less consistent, with null findings reported.

Conclusion: Because of the limited injury types studied and heterogeneity between study outcome measures and follow up, there is insufficient published evidence on which to calculate population estimates of long term morbidity, where injury is a component cause. However, the review does suggest injured people have an increased risk of long term HSU that is not accounted for in current methods of quantifying injury burden.

Priorities for injury prevention activities and planning for services depend on comprehensive knowledge of the distribution of the burden of injury related morbidity and mortality in the community.^{1–4} A systematic review of the literature was conducted to summarise available evidence on population based estimates of long term morbidity and health service use (HSU) attributable to injury and to quantify the effect of the key prognostic factors, injury type and severity, after controlling for potential confounding variables.

METHODS

Study question

What is the effect of being injured compared with not being injured on long term morbidity and HSU in working age adults?

Search strategy and inclusion criteria

The following sources were searched: Medline (1966–February 2005), PubMed (1966–February 2005), PsychINFO (1840–February 2005), CINAHL (1982–February 2005), Science Citation Index, and bibliographies of identified papers. Synonyms for the key components of the research question were included as search terms.

Studies were included in the review if they were population based cohort studies with a non-injured comparison group, and a sample size greater than 50 participants. Any long term morbidity and HSU outcomes reported in the literature were accepted, and “long term” was defined as occurring more than 12 months after the injury. Studies of people younger than 15 years or older than 65 years were excluded.

One author (CC) initially screened all titles/abstracts from the searches and identified 36 studies, which were population based and measured outcomes more than 12 months after injury. Two authors (CC and RM) then assessed these studies against the remaining inclusion criteria, with discordant assessments resolved by consensus. Nine studies met the criteria for this review.

Synthesis and standardisation of study results

Information extracted from the papers were summarised and presented in tabular and text form. Meta-analysis was not attempted because of the heterogeneity between studies. SMR-Exact (Simple Interactive Statistical Analysis, 1997, <http://home.clara.net/sisa/smrhlp.htm>) and Epi-Info (3.3 version, Epidemiology Program Office, Division of Public Health Surveillance and Informatics, 2004, <http://www.cdc.gov/epiinfo/>) were used to convert presented morbidity results to incidence rate ratios (IRRs) with 95% confidence intervals (CIs).

RESULTS

Study design, study populations, and case characteristics

Table 1 outlines the characteristics of the included studies. All of the studies had a retrospective cohort design. Sample sizes ranged widely from 198 to 311 006 injured cases. All but one study reported the mean age at the time of the injury was below 45 years.⁵ Two studies did not report the sex distribution.^{6,7} The proportion of men in the remaining studies ranged from 59.7% to 85%.

Outcome measurement

The studies were broadly classified by outcome measures into disease outcomes and post-injury HSU. Only outcome measures that were compared with non-injured samples or populations were of interest for this review and any other study outcomes are not reported here.

Confounding and loss to follow up

All studies adjusted for age and sex by comparing morbidity in the injured cases with either a matched non-injured group, or to age-sex standardised incidence rates from published national or census data. The one study that used a population based matched non-injured group did not adjust for potential

Abbreviations: CI, confidence interval; HI, head injury; HSU, health service use; IRR, incidence rate ratio; SCI, spinal cord injury; TBI, traumatic brain injury

Table 1 Characteristics and findings of long term morbidity for injured cases relative to non-injured comparison groups

Study	Injury type	Source population	Study size	Study population	Comparison group	Adjusting factors	Outcome measures	Results	95% Confidence intervals
Johnson <i>et al</i> , 1998 ⁹	SCI	Colorado, USA	917	Cases selected from state registry of SCI cases, alive at discharge from hospital, 1986–1993. All ages.	Age adjusted general population hospitalisation rates in 1990, USA.	Age	Incidence of post-injury hospitalisations compared to total population. Up to five years after injury.	Overall <15 years 15–44 years 45–64 years >65 years	IRR=2.00 IRR=4.10 IRR=2.10 IRR=2.40 IRR=0.90
Dryden <i>et al</i> , 2004 ⁸	SCI	Alberta, Canada	233	All cases hospitalised with injury diagnosis ICD-9 806 and 952 during April 1992 and March 1994.	Matched non-injured population (1:5). 1165 matched non-injured.	Matched on age, sex, and place of residence.	Incidence of all cause health service use and depression compared to matched non-injured comparison group. Up to six years after injury.	Hospitalisations Physician claims Hosp days per year Home care*	IRR=2.60 IRR=2.70 IRR=3.29 IRR=4.52 IRR=2.54 IRR=2.40 IRR=3.26
Savic <i>et al</i> , 2000 ¹⁰	SCI	Aylesbury and Southport, UK	198	Cases who participated in the ageing with spinal cord injury study. Ages 15–55 at the time of injury.	UK hospitalisation rates during 1994–1995.	None	Incidence of post-injury health service use compared with total population. Up to 52 years after injury.	Hospitalisations Hospitalisations Hospitalisations	IRR=6.5 IRR=3.2 IRR=3.9 IRR=39.5 IRR=29.4 IRR=20.5 IRR=5.6 IRR=9.2 IRR=13.7 IRR=175.7 IRR=1.20 IRR=2.20 IRR=0.90
Dowd <i>et al</i> , 1996 ¹¹	All injury	New Zealand	43507	All non-fatal cases hospitalised ICD-9 E800–E999 during 1990 (excl late effects, med and surg complications, legal interventions). All ages.	Age, sex standardised general population incidence rates of self injury.	Age, sex.	Incidence of assaultive injury hospitalisations compared with total population and stratified by intent of original injury. 12 months after injury.	Overall Non-assaultive Assaultive Undetermined	IRR=6.5 IRR=3.2 IRR=3.9 IRR=39.5 IRR=29.4
Cameron <i>et al</i> , 2003 ¹²	All injury	New Zealand	49683	All non-fatal cases hospitalised ICD-9 E800–E999 during 1997 (excl late effects, med and surg complications, legal interventions). All ages.	Age, sex standardised general population incidence rates of self injury.	Age, sex.	Incidence of self injury hospitalisations compared with total population and stratified by intent of original injury. 12 months after injury.	Overall Unintentional Assaults Undetermined	IRR=5.6 IRR=9.2 IRR=13.7 IRR=175.7 IRR=1.20 IRR=2.20 IRR=0.90
Nemetz <i>et al</i> , 1999 ⁵	TBI	Olmsted County, USA	1283	TBI diagnosed cases during 1935–1984, aged 40 or more at last contact. All ages.	Age, sex standardised population incidence rates of Alzheimer's disease in Rochester, Minnesota.	Stratified analyses for age, sex and time periods.	Incidence of Alzheimer's disease compared with total population. Excludes first six months after injury. Up to 53 years after injury.	Self injuries Overall Onset<75 years Onset>75 years	IRR=1.20 IRR=2.20 IRR=0.90
Annegers <i>et al</i> , 1998 ⁶	TBI	Olmsted County, USA	4541	TBI diagnosed cases during 1935–1984, excluding those with known epilepsy. All ages.	Age, sex standardised population incidence rates of unprovoked seizure disorders in Rochester, Minnesota.	Age, sex.	Incidence of unprovoked seizures compared with total population. Up to 60 years after injury.	Overall Mild Moderate Severe	IRR=3.10 IRR=1.50 IRR=2.90 IRR=17.0
Inskip <i>et al</i> , 1998 ¹³	HI	Denmark	228055	All cases hospitalised with injuries to the head, National Hospital Discharge Register 1977–1992. All ages.	Expected numbers of cancers calculated based on Danish population incidence rates.	Observed distribution of age, sex and calendar year of injury.	Incidence of intracranial tumours compared with total population. Up to 16 years after injury.	All cancer Year 1 After year 1	IRR=1.03 IRR=1.36 IRR=3.38 IRR=1.15
Nygren <i>et al</i> , 2001 ⁷	TBI	Sweden	311006	Cases identified from National Hospital Register discharges 1965–1994. All ages.	Age, sex standardised, year specific population incidence rates of brain tumours	Age at injury, sex, years of follow up, severity of injury.	Incidence of brain tumours compared with total population. Excludes first 12 months after injury. Up to 30 years after injury.	Overall	IRR=1.00

*Calculated from data presented. †Unable to calculate confidence intervals based on presented results. TBI, traumatic brain injury; SCI, spinal cord injury; HI, head injury; IRR, incidence rate ratio; ICD-9, International Classification of Diseases Revision 9; PYs, person years.

confounding by pre-existing conditions.⁸ Only three studies reported the proportions of injured cases lost to follow up.^{6,9,8} In these studies, losses over the respective study periods ranged from 10% to 30%.

Study findings

HSU outcomes

Studies examining rates of HSU after injury compared with that of the general population, found an overall association between injury and subsequent increased HSU (table 1). IRRs of all cause hospitalisations ranged from 2.0 to 2.6.

Dryden *et al*⁸ found cases with spinal cord injury (SCI) had 2.6 times the rate of hospital admissions (95% CI 2.3 to 3.0), 2.7 times the rate of physician claims (95% CI 2.6 to 2.71), 3.29 times the rate of stay in hospital per person year, and 4.52 times the number of people receiving home care services (95% CI 3.34 to 6.11) during the six year follow up period, relative to that of the non-injured. They also found rates of hospitalisations increased significantly in the first and second year after injury, decreased considerably by year three after injury. However, at no time did the rates of hospitalisations for the injured cases decrease to that of the non-injured.

Johnson *et al*⁹ showed during five years after injury, the cases of SCI had twice the rate of hospital admissions compared with rates in the general population. While the proportion of people being hospitalised decreased at each period of follow up, the adjusted average number of hospitalisations continued to exceed the total population ($p < 0.05$). Savic *et al*¹⁰ found cases of people with SCI, who were injured at least 20 years previously, had 2.4 times the rate of hospitalisations and 3.26 times the bed occupancy rate compared with the total population. Dowd *et al*¹¹ and Conner *et al*¹² found people who had been hospitalised for an injury had an increased risk of subsequent assaultive injury hospitalisations¹¹ and self injury hospitalisations.¹² Both studies showed that the IRRs increased with the intent of the original injury (table 1).

Disease outcomes

Studies examining the incidence of specific conditions after injury found differing estimates of effect (table 1). Annegers *et al*⁶ found an overall significant association between traumatic brain injury (TBI) and subsequent incidence of unprovoked seizures (IRR = 3.1, 95% CI 2.5 to 3.8). Nemetz *et al*⁷ found no significant differences in the incidence of Alzheimer's disease in people with TBI compared with that of the general population (IRR = 1.2, 95% CI 0.8 to 1.7). However, their results showed the time until onset of the disease may be reduced in people who have sustained a TBI. Inskip *et al*¹³ and Nygren *et al*⁷ found that after the first year after injury, there was no significant increase in intracranial tumours or brain tumours after sustaining a TBI compared with the general population (IRR = 1.15, 95% CI 0.99 to 1.32 and IRR = 1.00, 95% CI 0.9 to 1.2 respectively). Dryden *et al*⁸ identified that the cases with SCI were more than twice as likely to be treated for depression as the non-injured

(IRR = 2.54, 95% CI 1.95 to 3.31) during the six years of follow up.

DISCUSSION

The single most important finding of this review was the lack of empirical research from which burden of disease estimates can be derived. Only nine papers met the inclusion criteria for this review and all but two of these considered only a single injury type.

This review showed a positive association between injury and an increase in total HSU that exceeded that of the general population, which in some studies persisted up to 50 years after injury. The greatest excess in HSU was evident during the initial period after injury, but an increased risk remained for many years after injury. With the exception of one finding,⁹ all measures of increased risk of post-injury HSU were statistically significant. Disease outcome studies after injury were less consistent, with null findings reported.

In most studies, comparisons were made between outcomes in the injured group and age-sex standardised incidence rates from national statistics or census data. The flaw in this comparison is the implied assumption that before the injury event the two populations were the same. There is clear evidence, however, that injured cases are considerably different from the general population in terms of the prevalence of pre-existing comorbidities, alcohol use, and smoking.¹⁴⁻¹⁷ Comparing morbidity outcomes with general population disease incidence tables or population "norms" from national health surveys will not control for these confounders.^{15,18,19} No studies in this review attempted to control for pre-existing conditions in the injured and comparison populations.

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Policy implications

Indicators of the long term burden of injury are required to facilitate planning and monitoring health service needs and evaluating prevention and control strategies. These indicators need to be derived from the best available evidence. The review shows that current evidence is not sufficiently complete or detailed to support the required public health response.

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THE JECH GALLERY

Contrasts in public transport

An important aim of public policy in many countries is to increase the use of public transport, for both environmental and health reasons. However, bus stops may differ in their appearance in ways that may promote or discourage their use, for example, seating, the extent of graffiti, and protective barriers enclosing nearby trees and shrubs. Lack of perceived defensible space is associated with a heightened fear of crime¹ and may deter use, or invoke anxiety in users.

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