Economic and Health Impact of Injuries in the Netherlands and Europe

Suzanne Polinder-Korteweg

Economic and Health Impact of Injuries in the Netherlands and Europe

Kosten en ziektelast ten gevolge van ongevalsletsels in Nederland en Europa

Proefschrift

ter verkrijging van de graad van doctor aan de
Erasmus Universiteit Rotterdam
op gezag van de
rector magnificus
Prof.dr. S.W.J. Lamberts
en volgens besluit van het College voor Promoties.

De openbare verdediging zal plaatsvinden op
woensdag 10 januari 2007 om 11.45 uur

door

Suzanne Polinder-Korteweg

geboren te Kampen

Promotiecommissie

Promotor:	Prof.dr. J.D.F. Habbema
Overige leden:	Prof.dr. F.F.H. Rutten
	Prof.dr. G.J. Bonsel
	Prof.dr. P. Patka
Co-promotoren:	Dr. E.F. van Beeck
	Dr. W.J. Meerding

Colofon

ISBN-10: 90-8559-248-8
ISBN-13: 978-90-8559-248-8

Lay-out: Suzanne Polinder-Korteweg
Cover-illustration: Erik Varekamp
Printed by: Optima Grafische Communicatie Bv.
This thesis was printed with financial support of the J.E. Jurriaanse Stichting and the Department of Public Health, Erasmus MC, Rotterdam.

Publications

The chapters in this thesis are based on the following publications*:

Chapter 2: Lyons RA, Polinder S, Larsen CF, Mulder S, Meerding WJ, Van Beeck EF, and the Eurocost reference group. Methodological issues in comparing injury incidence across countries. International Journal of Injury control and Safety Promotion. 2006; 13: p. 63-70.

Chapter 3: Polinder S, Meerding WJ, Lyons RA, Toet H, Haagsma JA, Petridou E, Mulder S, van Beeck EF, and the Eurocost reference group. International variation in clinical injury incidence in ten European countries: performance of indicators based on health care, anatomical and outcome criteria? *Submitted.*

Chapter 4: Meerding WJ, Polinder S, Lyons RA, Toet H, Mulder S, van Beeck EF, and the Eurocost reference group. Injury incidence, health care consumption and costs of home and leisure injuries in seven European countries. *Submitted.*

Chapter 5: Polinder S, Meerding WJ, van Baar ME, Toet H, Mulder S, van Beeck EF, and the Eurocost reference group. Cost estimation of injury related hospital admissions in ten European countries. Journal of Trauma. 2005; 59: 1283-1291.

Chapter 6: Polinder S, van Beeck EF, Essink-Bot ML, Toet H, Looman CWN, Mulder S, Meerding WJ. Functional outcome at 2½, 5, 9 and 24 months after injury in the Netherlands. Journal of Trauma. *In press.*

Chapter 7: Polinder S, Meerding WJ, Toet H, Mulder S, Essink-Bot ML, van Beeck EF. Prevalence and prognostic factors of disability after childhood injury. Pediatrics. 2005; 116: 810-817.

Chapter 8: Polinder S, Meerding WJ, Mulder S, Petridou E, van Beeck EF, and the Eurocost reference group. Assessing the burden of injury in six European countries. Bulletin of the World Health Organization. *In press.*

Chapter 9: Polinder S, Meerding WJ, van Exel NJ, Brouwer WBF. Societal discounting of health effects in cost-effectiveness analyses: the influence of life expectancy. Pharmacoeconomics. 2005; 23: 791-802.

---

* Reprinted with kind permission of International Journal of Injury control and Safety Promotion (chapter 2), Journal of Trauma (chapter 5 & 6), Pediatrics (chapter 7), Bulletin of the World Health Organization (chapter 8), and Pharmacoeconomics (chapter 9).

Contents

1

General introduction

Assessing the economic and health impact of injuries

Injury is a major public health problem. It is a leading cause of death and disability throughout the world [1, 2]. Injuries also pose a serious burden on society because of the considerable health care costs involved, apart from productivity loss due to temporary or permanent disability. Investigation of the socio-demographic, health care related and geographic determinants of the economic and health impact of injuries may serve to develop preventive interventions and to improve health care.

Injuries range from frequent minor injuries (e.g. superficial injuries) to rare major injuries (e.g. polytrauma). As a consequence, injuries result in a wide array of individual patters of medical consumption and functional outcome. This heterogeneity puts specific demands on data sources for the measurement and valuation of incidence, functional outcome, and costs of injury in a national and international context. For instance, injury incidence is usually only measured in health care settings and is therefore influenced by (inter)national differences in the threshold for care-seeking and the registration practice in the various health care settings. Functional outcome data are rarely registered and require dedicated measurements, which in turn requires choices on e.g. measurement intervals and health status measures. Finally, available cost related data from registries are incomplete from an economist point of view. If available, their linkage is complex due to the heterogeneity of injuries, giving rise to costs from primary care to high-technology trauma care, rehabilitation services and long term care.

Current analytical tools for describing the health and economic impact of disease and injury are the burden of disease (BOD) methodology and cost of illness (COI) methodology (Figure 1.1). BOD and COI methods provide a comprehensive and coherent description of the health and the economic impact of injury, respectively, and of their distribution across injuries, risk factors, and other variables [3]. In BOD studies summary measures of population health combine information on premature mortality and disability. In COI studies costs summarize the health care utilization. Data on disease burden and (health care) costs of illnesses are a crucial input to economic evaluation studies. Provided that comparative data are available, combined BOD/COI data give insight into the (potential) changes in costs and population health as a result of a particular intervention or a combination of interventions.

So far, within Europe, several studies on the economic [4-9] and health impact [10-16] of injuries were conducted. They are generally limited to specific injuries, countries, health care sectors, and age groups. These studies, however, show large differences with respect to their methodology, in particular in the way they measure and value the economic and health consequences of injuries. For that reason even specific studies on the same issue can rarely be compared or combined. We assume that the heterogeneity of injuries itself is a major contributing factor to the incomparability of methods. This thesis aims therefore to contribute to the development and application of harmonization procedures allowing for comparable BOD and COI studies in the field of injuries.

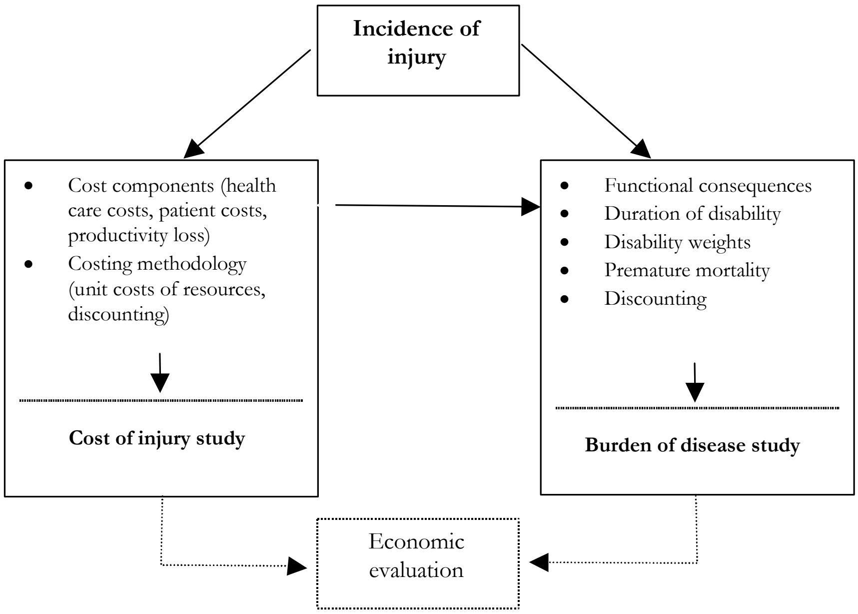


Figure 1.1 Conceptual model

Note figure 1.1: patient costs and productivity losses are no subject of the thesis

Injury incidence

Although BOD and COI methods provide a framework for measuring the health and economic impact of injuries, the study results depend on the quality of the data, in particular the epidemiological data. For instance, disability weights to reflect injury severity are of no use when they are inconsistent with data on injury incidence, or when incidence data are incomplete [17]. As for injury incidence data, there are a number of hurdles to overcome, especially in an international context.

Even if the injury is 'detected' through a health care setting the definition of injury, classifications and inclusion criteria can differ. There is an international scientific debate taking place about several methodological 'data issues' in determining the injury incidence [18-23]. Differences in surveillance data are generally caused by the definition and classification of injury, proportions of missing data, and the handling of readmissions and day case admissions. The differences in health care policy are mainly caused by international differences in hospital admission policy and primary care givers that act as gatekeepers. The (international) variation in injury incidence due to variation in health care policy and registration bias can be decreased using a uniform severity threshold for the case definition [24]. The resulting injury indicator ideally denotes or reflects, directly or indirectly, variations and trends in injuries, or injury-related or injury control-related phenomena [25, 26]. Several indicators have been proposed recently [19, 21, 23, 24, 27], but there remains a debate as to what the appropriate indicators for the incidence of injury should be. The further development of methods for data standardization and injury indicators can contribute to the comparability of injury incidence data both at national and international level and provides the foundation for the scientific basis of injury prevention. The first research question will therefore be:

Research question 1: How can the international comparability of injury incidence data be improved?

Chapter 2 addresses several methodological issues for measuring injury incidence, including the definition of injury to be used, the cross-national comparability of available data systems, consideration of robust indicators, and methods to assess the validity of data extrapolated from incomplete surveillance systems. **Chapter 3** deals with the development and validation of injury indicators by testing already proposed and newly developed indicators to injury incidence data across European countries. The aim of this chapter is to analyse international variation in clinical injury incidence, and to determine whether using different injury indicators minimizes bias and increase the comparability of injury incidence data.

Economic impact of injury

Injuries are a major cause of health care costs, comparable to cancer and stroke [3]. Being a unidimensional measure, costs enable rapid comparisons among types of injury that differ with respect to severity and health care need [28, 29]. Comprehensive and detailed information on health care costs may help to identify injuries and high risk-groups to be considered for potential intervention [30]. There is a considerable variety in COI studies [31]. They may be restricted to health care costs, or also include costs to patients and other economic sectors (e.g. productivity losses). They may be disease-specific, describing the costs of specific diseases, or generic, giving a comprehensive overview of costs of the entire spectrum of diseases. A related distinction is between top-down and bottom-up studies [32]. Total (health care) costs in a specified period can be attributed top-down to specific diseases, injuries and risk factors. This has the advantage that a uniform methodology is applied for all diseases, and facilitates the comparison of costs across different health problems. In a bottom-up approach, often used in disease-specific studies, lifetime health care consumption is related to incidence in a given period. Disease-specific incidence based COI studies may use detailed data sets that are not available for generic prevalence based COI studies, and therefore may give more detailed and reliable results.

An international comparison of health care costs of injury can both show common problems for several countries, as well as specific problems for individual countries. So far, cost of injury studies have been limited to specific countries, injuries, health care sectors, and age groups [7, 9, 33, 34]. Because of incomparable methods, the differences and commonalities of medical costs of injury between European countries are not known. In this thesis a disease-specific incidence based COI study has been conducted for injuries in Europe, by which health care costs of injury were estimated bottom-up. We addressed the following research question:

Research question 2: What are the medical costs of injury in European countries and can international variation be explained?

In **chapter 4** an overview is given of the variation in clinical injury incidence, healthcare consumption and medical cost of injuries in Europe, and provides some explanations for this variation. **Chapter 5** describes the costs of injury related hospital admissions in Europe, subdivided by country, socio-demographic, and injury related factors. Hospital discharge information from 10 European countries was used to examine the use of hospital resources for injured patients and to identify population groups that are not only most vulnerable to injury but also the most costly.

Health impact of injury

BOD studies provide comparative information on population health across disease groups, population groups, country, and time [35]. Summary measures of population health play a key role in BOD studies. They integrate data on premature mortality and years lived with disability to describe the burden of disease of a population in a single metric, namely disability adjusted life years (DALYs) [36].

To make valid estimates of the burden of disease due to injury, sound epidemiological data on the incidence, severity and duration of the health consequences (functional outcome) of injuries are a prerequisite. A conceptual framework for measuring the functional outcome is provided by the International Classification of Functioning, Disability and Health (ICF). The ICF distinguishes between functioning and contextual factors [37]. Functioning encompasses the level of body functions, activities and participation in life situations. The severity can be measured with specific instruments for the valuation of health states. Many instruments have been developed for measuring functioning. A general distinction is between generic instruments and disease- or domain-specific instruments. Generic instruments include items on all three domains of health: physical, mental and social functioning. With some of these instruments, the resulting health profiles can subsequently be converted into a unidimensional measure by using an existing algorithm. For instance, such algorithms are available for the EuroQol and SF-6D (based on the SF-36) generic instruments, based on statistical modeling of empirical valuations of a set of key health state descriptions [38, 39]. These instruments are applicable to all diagnoses, and are therefore useful to make comparisons among diseases or injuries that may be quite different. Disease-specific instruments describe the functional consequences of all possible diseases and injuries and their different disease stages, and subsequent valuation of these descriptions by one or several valuation techniques. As a result they are more sensitive to specific changes in health, but cannot be used to make comparisons across different health problems. Domain specific instruments focus on specific types of functioning e.g. pain or depression. Considering the wide spectrum of possible diagnoses, even within the field of injury, this would at least be time consuming. Typical for injuries are their heterogeneous functional sequelae and recovery patterns both in the short- and the long-term. Injuries can struck any body region, and multiple mechanisms (fall, fire, chemical substance, etcetera) lead to evenly multiple types of injury (fracture, strains, burns, etcetera). The EuroQol enables a uniform comparison of injuries among each other and with other health problems [40], and has therefore been used in this thesis.

The burden of non-fatal health outcomes and of premature mortality constitutes the Disability Adjusted Life Years (DALYs). DALYs take into account the premature loss of life from deaths using years of life lost, and the period spent without full health for non-fatal conditions as measured by years lived with disability (YLDs). DALYs provide a means of combining the impact of fatal and non-fatal outcomes in a single measure. In particular, the DALY measures the gap between population's actual health status and some 'ideal' or reference status [41]. The DALY was designed to assess the burden of disease beyond mortality aimed for national and international health policies, to develop unbiased epidemiological assessments for major disorders, and to provide an outcome measure that could also be used for cost-effectiveness analysis [42]. The value of the DALY as a tool for health policy and planning purposes has been increasingly recognized [43]. DALYs have been estimated in several studies, which have already produced some estimates on DALYs attributable to injury. These studies have used expert opinion based estimates of injury-related disabilities [44]. It has been argued, that the collection of empirical data on the functional consequences of diseases and injury increases the validity of BOD calculations [17]. However, comparable and representative epidemiological data on the incidence, severity and duration of injury-related disabilities are still scarce and incomplete. So far, studies on functioning mainly focused on hospitalized patients, for instance among severely injured trauma patients [10-12] or specific serious injuries [45]. Little is known about the non-hospitalized patients, who are likely to have minor disability levels with short durations [16]. Nevertheless, a considerable share of total disability may be attributable to patients that have never been hospitalized [46-48]. Furthermore, assessment of patient outcome after injury for children has so far mainly focused on the psychological effects [49, 50] or only on the most severely injured trauma patients, including children with traumatic brain injury [51-53]. Few studies have described the impact of injuries on the health status of children with both minor and major injuries over time with a generic quality of life instrument [54, 55]. Moreover, little is known on the recovery patterns and long term consequences of injury patients, since previous studies with a longitudinal design and multiple measurements over time are scarce [11, 16]. The third research question will therefore be:

Research question 3: What is the health impact of injury in terms of functioning and burden of disease, and can international variation be explained?

We conducted a follow-up study of short- and long-term functional outcome in a comprehensive population of hospitalized and non-hospitalized non-fatal injury patients who visited an Emergency Department in the Netherlands. It provided uniform data on the levels of functioning and disability at four points in time till two years after injury, which gives information about the recovery pattern of injury patients. **Chapter 6** describes how levels of functioning differ by type of injury for hospitalized and non-hospitalized patients (aged 15+), and how functioning is determined by socio-demographic, injury, and health care related factors in the short-term and long-term. **Chapter 7** focuses on the functional outcome of injured children aged 5-14 years in the Netherlands and on predictive factors for sub-optimal functioning in the long term.
The health impact of injury in terms of DALYs in the European Region by country, age, sex, injury type and external cause has hardly been studied. Therefore, in **chapter 8**, we attempted to asses the burden of disease as a consequence of injury - expressed in the summary measure of DALYs and its comprising components, namely premature mortality (years of life lost, YLL) and years lived with disability (YLD) - in six European countries. Variation in the burden of disease among injury patients in the European countries, may be due to differences in exposure, injury risk and type of injury, differences in demography, (socio)-economic and cultural factors, safety technology, injury prevention strategies, as well as in the effectiveness of medical care delivery at national level after the injury occurs. Assessment of the variation and its constituent components can be used in order to identify high-risk groups in Europe and specific countries and prioritize injury prevention programs.

The (health care) costs and health consequences of injuries extend over several years. In BOD and COI studies, future costs and health consequences are valued less than current costs and health consequences. However, this practice is controversial. For costs it is argued that money can earn interest when invested (opportunity costs of capital). Future health consequences are discounted because of time preference, uncertainty about the future, and increasing life expectancy [56, 57]. As a result, in BOD and COI studies future cost and benefits are discounted to reflect their present value. The discounting debate concerns the arguments why discounting is applied, the appropriate discount rate, the shape of the discount function, and finding an objective measure for relevant differences (between people) over time. While the standard practice is to discount both costs and effects with a three to five percent discount rate [32, 58], many have raised questions about this practice [56, 59, 60]. In **chapter 9** an overview is given of the theoretical debate on appropriate discount procedures. It is an important topic from a practical perspective since the choice of the discount rate used can alter the results of BOD and COI studies (and of economic evaluation studies) considerably. Empirical research is done to affirm the differences in time preferences for health and for money. Furthermore, increasing life expectancy and decreasing marginal valuation of additional QALYs over time has been put forward as an argument for discounting future health effects from a societal perspective [56]. Therefore, we tested the hypothesis that societal time preference for health is related to perceived future life expectancy. Furthermore, the appropriateness of discounting in descriptive analyses is discussed.

In summary, the analytical tools as described in this thesis – COI and BOD – are strongly related to each other and are complementary with respect to informing health care policy and planning. Nevertheless, questions remain about their relative contribution, of which this thesis presents some examples. In **chapter 10** the main conclusions are summarized and discussed. Economic evaluation studies combine COI and BOD studies and provide insight into the (potential) changes in costs and population health as a result of a particular intervention. Difficult choices must be made in setting priorities for injury prevention and control and allocating scarce resources between alternative uses [61]. For example, should more resources be allocated to falls prevention programs, water safety programs, or violence prevention programs? Within the falls prevention area, should more resources be allocated to reducing the current rate of falls by preventing injury in the high-risk population or to reducing the future rate of falls by generating a low-risk population by wide-ranging prevention programs? Such choices are difficult to make. Economic evaluation studies can contribute to these decisions by providing information on those interventions with the most favorable balance between costs and health effects. In the discussion section an example is given of a cost-effectiveness analysis of preventive fall reduction interventions in elderly in the Netherlands. In this example the COI and BOD method, as described in this thesis, were applied and mutually connected with each other. We also put forward the possible implications for further research and health care policy.

References

1. Murray, C.J. and A.D. Lopez, Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. The Lancet, 1997. 349(9063): p. 1436-42.
2. Morrison, A., D.H. Stone, and EURORISC working group, Injury mortality in the European Union 1984-1993. Eur J Public Health, 2000. 10: p. 201-7.
3. Meerding, W.J., describing health and medical costs, and the economic evaluation of health care: applications in injuries and cervical cancer (thesis). 2004, Erasmus University: Rotterdam.
4. Lindqvist, K.S. and H. Brodin, One-year economic consequences of accidents in a Swedish minicipality. Accident Analysis and Prevention, 1996. 28: p. 209-219.
5. Kopjar, B., Costs of health care for unintentional injury in Stavanger, Norway. European Journal of Public Health, 1997. 7(3): p. 321-327.

6. Bauer, R., Overall costs to the Austrian national economy from home and leisure accidents. European Journal of Consumer Safety, 1995. 2(7).
7. Van Beeck, E., Medical costs and economic production losses due to injuries in the Netherlands. Journal of trauma, 1997. 42: p. 1116-1123.
8. Kidholm, K. and J. Soegaard, A study of the cost of injury in road accidentes (in Norwegian), in CHS working paper, O.U. Press, Editor. 1997.
9. Bastida, J.L., P.S. Aguilar, and B.D. Gonzalez, The economic costs of traffic accidents in Spain. J Trauma, 2004. 56(4): p. 883-8; discussion 888-9.
10. Vles, W.J., E.W. Steyerberg, M.L. Essink-Bot, E.F.v. Beeck, et al., Prevalence and determinants of disabilities and return to work after major trauma. J Trauma, 2005. 58: p. 126-135.
11. Holbrook, T.L., J.P. Anderson, W.J. Sieber, D. Browner, et al., Outcome after major trauma: 12-month and 18-month follow-up results from the Trauma Recovery Project. J Trauma, 1999. 46(5): p. 765-71.
12. Holbrook, T.L. and D.B. Hoyt, The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. J Trauma, 2004. 56(2): p. 284-90.
13. Anke, A.G., J.K. Stanghelle, A. Finset, K.S. Roaldsen, et al., Long-term prevalence of impairments and disabilities after multiple trauma. J Trauma, 1997. 42: p. 54-61.
14. Baldry Currens, J.A., Evaluation of disability and handicap following injury. Injury, 2000. 31: p. 99-106.
15. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. J Trauma, 2000. 48(5): p. 841-850.
16. Meerding, W.J., C.W. Looman, M.L. Essink-Bot, H. Toet, et al., Distribution and determinants of health and work status in a comprehensive population of injury patients. J Trauma, 2004. 56(1): p. 150-61.
17. Essink-Bot, M.L. and G.J. Bonsel, How to derive disability weights, in Summary measures of population health: concepts, ethics, measurement and applications, C.J.M. Murray, et al., Editors. 2002, World Health Organization: Geneva.
18. Langley, J. and R. Brenner, What is an injury? Injury Prevention, 2004. 10: p. 69-71.
19. Langley, J., S. Stephenson, C. Cryer, and B. Borman, Traps for the unwary in estimating person based injury incidence using hospital discharge data. Inj Prev, 2002. 8(4): p. 332-7.
20. Cryer, P.C., S.N. Jarvis, P. Edwards, and J.D. Langley, How can we reliably measure the occurrence of non-fatal injury? Int J Consum Prod Saf, 1999. 6(4): p. 183-91.
21. Cryer, C., J.D. Langley, S.C. Stephenson, S.N. Jarvis, et al., Measure for measure: the quest for valid indicators of non-fatal injury incidence. Public Health, 2002. 116(5): p. 257-62.
22. Lyons, R.A., S. Jones, A. Kemp, J. Sibert, et al., Development and use of a population based injury surveillance system: the all Wales Injury Surveillance System (AWISS). Inj Prev, 2002. 8(1): p. 83-6.
23. McClure, R.J., N. Peel, D. Kassulke, and R. Neale, Appropriate indicators for injury control? Public Health, 2002. 116(5): p. 252-6.
24. Cryer, C., J.D. Langley, S.N. Jarvis, S.G. Mackenzie, et al., Injury outcome indicators: the development of a validation tool. Inj Prev, 2005. 11: p. 53-57.
25. Cryer, C., J. Langley, and S. Stephenson, Developing valid injury outcome indicators: a report for the New Zealand injury prevention strategy, O.R.O. 049, Editor. 2004, Occasional Report OR 049: Dunedin, New Zealand.
26. Cryer, C., Injury outcome indicators - validation matters. International Journal of Injury control and Safety Promotion, 2005. 12(4): p. 219-224.
27. Cryer, C. and J. Langley, Developing valid indicators of injury incidence for 'all injury'. Inj Prev, 2006. 12: p. 202-207.
28. Mackenzie, E.J., J.H. Siegel, S. Shapiro, M. Moody, et al., Functional recovery and medical costs of trauma: an analysis by type and severity of injury. J Trauma, 1988. 28: p. 281-297.

29. Segui-Gomez, M. and E.J. Mackenzie, Measuring the Public Health impact of injuries. Epidemiol Rev, 2003. 25: p. 3-19.
30. Mulder, S., W.J. Meerding, and E.F. Van Beeck, Setting priorities in injury prevention: the application of an incidence based cost model. Inj Prev, 2002. 8(1): p. 74-8.
31. Polder, J.J., Cost of illness in the Netherlands (thesis). 2001, Erasmus University: Rotterdam.
32. Gold, M.R., J.E. Siegel, L.B. Russel, and M.C. Weinstein, Cost-effectiveness in health and medicine, ed. O.U. Press. 1996, New York.
33. Lindqvist, K.S. and H. Brodin, One-year economic consequences of accidents in a Swedish municipality. accid anal and prev, 1996. 28(2): p. 209-219.
34. Kopjar, B., Costs of health care for unintentional injury in Stavanger, Norway. Eur J Public Health, 1997. 7: p. 321-327.
35. Maas van der, P.J., Applications of summary measures of population health, in Summary measures of population health: concepts, ethics, measurement and applications, C.J.M. Murray, et al., Editors. 2002, WHO: Geneva. p. 53-60.
36. Field, M.J. and M.R. Gold, summarizing population health: directions of the development and application of population metrics. 1998, Washington D.C.: National Academy Press.
37. International classification of functioning, disability and health: ICF. 2001, World Health Organization: Geneeva.
38. Brazier, J., J. Roberts, and M. Deverill, The estimation of a preference-bases measure of health from the SF-36. J Health Econ, 2002. 21: p. 271-92.
39. Dolan, P., Modeling valuations for EuroQol health status. Med Care, 1997. 35: p. 1095-1108.
40. Meerding, W.J., C.W.N. Looman, M.L. Essink-Bot, H. Toet, et al., Functioning and work status of hospitalized patients at 2, 5 and 9 months after injury. Submitted, 2004.
41. Mathers, C., T. Vos, and C. Stevenson, The burden of disease and injury in Australia, AIHW, Editor. 1999, AIHW: Canberra.
42. Murray, C.J.L. and A.D. Lopez, Mortality by cause for eight regions of the world: Global Burden of Disease Study. The Lancet, 1997. 349: p. 1269-1276.
43. The world health report 2000. Health systems: improving performance., World Health Organization, Editor. 2000: Geneva.
44. Murray, C.J.L. and A.D. Lopez, The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Global Burden of Disease and injury series. 1996, Boston: The Harvard School of Public Health.
45. Mackenzie, E.J., B.M. Cushing, G.J. Jurkovich, J.A. Morris, et al., Physical impairment and functional outcomes six months after severe lower extremity fractures. Journal of Trauma, 1993. 34: p. 528-38.
46. Waller, J.A., J.M. Skelly, and J.H. Davis, Emergency department care and hospitalization as predictors of disability. J Trauma, 1995. 39: p. 632-4.
47. McClure, R.J. and R.M. Douglas. The public health impact of minor injury. Accid Anal Prev, 1996. 28 (4): p. 443-51.
48. Polinder, S., W.J. Meerding, H. Toet, S. Mulder, et al., Prevalence and prognostic factors of disability after childhood injury. Pediatrics, 2005. 116: p. 810-817.
49. Stallard, P., R. Velleman, and S. Baldwin, Prospective study of post-traumatic stress disorder in children involved in road traffic accidents. BMJ, 1998. 317: p. 1619-1923.
50. Ellis, A., G. Stores, and R. Mayou, Post-traumatic stress disorder in children and adolescents following road traffic accidents. Br J Psychiatry, 1998. 172: p. 443-447.
51. Harris, B.H., S.D. Schwaitzberg, T.M. Seman, and C. Herrmann, The hidden morbidity of pediatric trauma. J Pediatr Surg, 1989. 24(1): p. 103-5.
52. Tursz, A. and M. Crost, Sequelae after unintentional injuries to children: an exploratory study. Injury prevention, 2000. 6: p. 209-213.

53. Stancin, T., D. Drotar, H.G. Taylor, and K.O. Yeates, Health-related quality of life of children and adolescents after traumatic brain injury. Pediatrics, 2002. 108: p. E34.

54. Sturms, L.M., C.K. Sluis, J.W. Groothoff, H.J. Duis ten, et al., Young traffic victims' long-term health-related quality of life: child self-reports and parental reports. Arch Phys Med Rehabil, 2003. 84: p. 431-6.

55. Aitken, M.E., J.M. Tilford, K.W. Barrett, J.G. Parker, et al., Health status of children after admission for injury. Pediatrics, 2002. 110: p. 337-342.

56. Van Hout, B.A., Discounting costs and effects differently: a reconsideration. Health Econ, 1998. 7: p. 581-594.

57. Brouwer, W.B.F., B.A. van Hout, and F.F.H. Rutten, A fair approach to discounting future effects: taking a societal perspective. J Health Service Research and Policy, 2000. 5(2): p. 114-118.

58. Drummond, M.F., B. O'Brien, G.L. Stoddard, and G.W. Torrance, Methods for the economic evaluation of health care programmes. 2nd ed. 1997, Oxford: Oxford University Press.

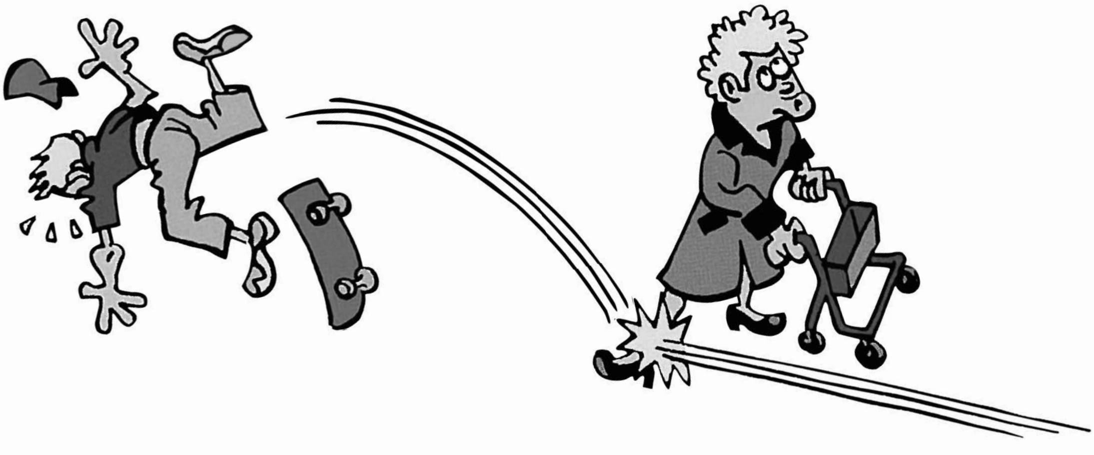
59. Lazaro, A., Theoretical arguments for the discounting of health consequences; Where do we go from here? Pharmacoeconomics, 2002. 20(14): p. 943-961.

60. Parsonage, M. and H. Neuburger, Discounting and health benefits. Health Econ, 1992. 1: p. 71-76.

61. McClure, R.J., M. Stevenson, and S. McEvoy, The scientific basis of injury prevention and control. 2004, Melbourne: IP communications.

Part I

Comparability of Injury incidence data



2

Methodological issues in comparing injury incidence across countries

Ronan A. Lyons, Suzanne Polinder, Claus F. Larsen, Saakje Mulder,Willem Jan Meerding ,
Ed F. Van Beeck, and the EUROCOST reference group
International Journal of Injury control and Safety Promotion. 2006; 13(2): 63-70

Abstract

The primary objective was to describe the methodological challenges and devise solutions to compare injury incidence across countries. The research design was a mixed methods study, consisting of a consultation with an expert group and comparison of injury surveillance systems and data from then European countries. A subset of fractures, selected radiologically verifiable fractures, and a method of checking the national representativeness of sample emergency department data were devised and are proposed for further development.

These methodological considerations and developments will be further refined and tested and should prove useful tools for those who need to compare injury incidence data across countries.

Introduction

There is a desire and need to compare injury incidence between countries in order to study the relationship between exposure to hazardous and safety practices and injury occurrence and how these relate to different policies. This is difficult to do for non-fatal injuries as there are no comparative surveys of non-fatal injuries and incidence is therefore measured by health service utilisation. The European Commission funded the EUROCOST project to estimate the direct medical costs of treating injuries in Europe [1]. In order to carry out this work, it was necessary to address several issues, including the definition of injury to be used, the availability of similar data across countries, consideration of robust indicators, and methods to assess the validity of data extrapolated from incomplete surveillance systems.

This chapter describes the methodological challenges identified in trying to carry out this work and the solutions proposed to overcome these difficulties. There issues are pertinent to anybody carrying out cross-national comparisons of injury incidence data.

Materials and methods

Definition of injury

The first issue to arise in this complex project was the definition of injury to be used. This is not a trivial issue as recently demonstrated by Langley and Brenner [2]. After some discussion we based our operational definition on physical injuries defined as relatively sudden discernible effects due to body tissue damage from energy exchanges or ingestion of toxic substances but not due to medical adverse events, and obtained from health care settings. This is equivalent to ICD9 external causes E800-E999, excluding E870-E876, E878-E879, E930-E949 and ICD10 codes V01-Y98 minus Y40- Y89.

International availability of comparable data

The second issue to arise was to decide on what injury data could be used for each country and how to interpret the data in the light of vastly different health care administrations. In order to do this a comprehensive injury occurrence and acute health care flow diagram was produced. This is shown in figure 2.1 with points indicating where incident cases could theoretically be captured in emergency department (EDs), hospital discharge registers (HDRs), and mortality statistics. The initial diagram was developed by two of the authors with clinical experience (R.A. Lyons and C.F. Larsen) and refined with the input of the other 13 members of the group from ten European countries. The first thing to note with this diagram is that the true incidence of injury can never be accurately measured. This is because many trivial injuries pass unnoticed, e.g. bruising with no recollection of an injury event. Thus, it is common to use a severity indicator to define an injury for the purposes of counting incidence. The reason for adopting an approach using routine administrative databases is that there are no survey data that can be compared across different countries.

The recent guidelines on conducting community surveys on injuries and violence produced by the World Health Organization shows clearly how variations in content, coverage, classification, definition and coding between countries means that current surveys cannot be compared [3]. In addition, in order to break down costs by anatomical injury common systems of injury classification are required but these are rarely found in self-completed survey data. Consequently, coded injury data were sought from administrative systems in each country.

In surveys, the definition of severity will often be based on healthcare attendance, usually medical, for the injury or a period of restricted activity. Neither of these can be described as a reliably objective measure of severity. There is a growing literature on the effect of non-injury factors on attendance at an emergency department or admission to hospital [4-6].

The second thing to note with the diagram is the complexity of the patient flows and how these might affect injury registration at the three levels (ED, HDR and mortality statistics). It is not intended that each country completes the data for each of the 43 flows, as specific studies to accurately measure these will not have been undertaken. Nevertheless, consideration as to whether each of the patient flows exists, and expert judgement on the perceived extent in different countries is crucial to the interpretation of data comparisons.

An analysis of the systems and data availability in ten countries participating in the EUROCOST study revealed that all could provide data from ED and HDR systems. HDR systems are relatively standardised across countries and use ICD-9 or ICD-10 codes, making the process somewhat easier, although the basis of individual records varies across countries where records can relate to an individual, an injury, or perhaps different definitions of a period of care for that individual by different doctors or hospitals. Some countries could provide data on all injuries, some only on unintentional injuries and some only on unintentional home and leisure injuries. The latter was the minimum requirement for participation in the study.

The coding structure of ED data is very variable both within and between countries. Due to the large numbers attending, which typically is around ten times the numbers admitted, few places have the resource to ICD code diagnoses in the ED setting. Most systems are organised for administrative convenience of the medical staff and contain groupings of diagnoses, which make clinical sense to the developers and clinicians. However, the number and combination of groups vary between systems, in part, due to the plethora of ED computer systems available. Based on the earlier work of the Dutch cost model a common grouping of 39 injury categories was agreed for comparative purposes (Table 2.1) [7]. The ICD codes for these categories are shown in the table in Appendix 2.A.

Table 2.1 Injury groups in the EUROCOST model

Injury group name	Injury group number
Head injuries	
Concussion	1
Other skull-brain injury	2
Open wound of head	3
Face injuries	
Eye injury	4
Fracture of facial bones	5
Open wound of face	6
Vertebral and Spinal injuries	
Fractures/dislocations/sprain/strain	7
Whiplash/neck sprain/distortion of cervical spine	8
Spinal cord injury	9
Abdominal and Thoracic injuries	
Internal organ injuries	10
Fracture of rib/sternum	11
Upper extremity injuries	
Fracture of clavicle or scapula	12
Fracture of upper arm	13
Fracture of elbow or forearm	14
Fracture of wrist (incl. Carpal bones)	15
Fracture of hand or fingers	16
Dislocation/sprain/strain of shoulder or elbow	17
Dislocation/sprain/strain of wrist or hand or fingers	18
Injury to nerves	19
Complex soft tissue injuries	20
Lower extremity	
Fracture of pelvis	21
Fracture of hip	22
Fracture of femoral shaft	23
Fracture of knee or lower leg	24
Fracture of ankle	25
Fracture of foot (excludes ankle)	26
Dislocation/sprain/strain of knee	27
Dislocation/sprain/strain of ankle or foot	28
Dislocation/sprain/strain of hip	29
Injury to nerves	30
Complex soft tissue injury	31
Minor external injuries	

Injury group name	Injury group number
Superficial injury (including contusions and bruises)	32
Open wounds	33
Burns	34
Poisoning	35
Multi trauma	36
Other injuries	
Foreign body	37
No injury after examination	38
Other and unspecified injury	39

Robust injury indicators

Previous work has shown that most injuries attending EDs are relatively minor and options of self-care or care at another type of facility exists. Population-based systems are capable of measuring the magnitude of this potential bias. In Wales, childhood attendances for all injuries at EDs decrease by 50% over a 10-mile distance but with no decline noticeable for fractures [8]. This led to the consideration of using fracture incidence data as an injury indicator. During the work on the EUROCOST project we refined our thinking of this indicator and have a defined subgroup of fractures, selected radiologically verified fractures (SRVFs), which make sense from a combined clinical, data collection and coding perspective. They are based upon a lowest common denominator of the grouping of diagnoses commonly used in ED systems and are listed in table 2.2.

Data collection and analysis

Individual level anonymized data on patients attending an ED or admitted to hospital with an injury (codes specified in Appendix 2.A) were collated from routine data systems from the participating countries for the year 1999. Data were supplied from Austria, Denmark, England, Greece, Ireland, Italy, the Netherlands, Norway, Spain, and Wales. National and local population profiles in 5-year age groups were also provided to allow calculation of age specific and standardised rates. All data were provided to one of the authors (S. Polinder) in the Netherlands who analysed the data. Analyses and their interpretation were discussed by the project team and reference group at meetings held in Amsterdam, Swansea and Barcelona. The methods of data collection and analysis have been described in detail in the final report of the EUROCOST project [1].

Derivation of incidence rates from emergency department data

Another issue that arises in the use of ED injury data to estimate incidence is the correct estimation of population rates from sample data. In most countries injury surveillance at ED level is based on a sample of participating departments and an extrapolation factor is needed to move from a measured sample incidence to a population estimate.

Table 2.2 Selected Radiologically Verified Fractures

1	Upper arm
2	Elbow and forearm
3	Wrist including carpal bones, except in age < 5 years
4	Pelvis
5	Hip including femoral neck and inter-trochanteric fractures
6	Femoral shaft
7	Knee and lower leg
8	Ankle

There are two principal methods of providing such extrapolation factors:

1. A detailed small area analysis around participating EDs to develop an appropriate catchment area and then a factor applied to the difference between the sample catchment area and the total population – the approach used in Wales.
2. An extrapolation factor based upon total attendances at all EDs in the country and the proportion attending the sample – the approach used in other countries.

Clearly, accuracy in the extrapolation factor is essential in producing accurate incidence data. As the proportion of total cases seen in the sample EDs decreases there is greater possibility of error in measuring or estimating the extrapolation factor. In this group of 10 countries coverage of the EDs varied from 2% (4 hospitals) in Austria to 100% in Italy (but only for occupational injuries), with most covering less than 20% [1]. The UK HASS and LASS system's extrapolation factor is based on total first time attendances at 16-18 EDs as a proportion of all first time attendances at all EDs, with the participating departments covering 5% of the total. The Dutch ED system (LIS) has a coverage of 15% (17 hospitals) of all general and academic hospitals with ED's. Also in Denmark and Greece the ED systems cover approximately 15% of the population, although in Greece the system relies mostly on urban and younger population groups [9]. The ED system of Ireland is based on two hospital ED's (7% coverage), one in a county town with a large rural population and the other in a suburb of a small city with a mixed urban-rural population. The ED system of Norway covers 5% of total ED patients, with an overrepresentation of the urban areas. In Wales, the ED system includes 11 hospitals covering 61% of the population. Extrapolation assumes that the sample EDs are representative of the population of EDs. An individual ED could provide a biased sample if it were located in an area with a very young or old population or where any of the other determinants of injury or injury attendance are selectively concentrated. One method to check the representativeness of the sample is to compare hospital admission rates in the sample (from the ED) records with the overall hospital admission rates available from the HDR systems. A sample based on 10% of EDs should produce 10% of the injury

Table 2.3 Standardised ED based incidence rates per 1000 population (number) for all home and leisure patients and selected radiologically verified fractures (SRVFs) (due to home and leisure injuries) by country

	All Cases		**SRVFs**		**Percentage of SRVFs among all cases**
Country	**Rate**	**Number**	**Rate**	**Number**	
Austria	59.0	483 406	17.3	144 308	30
Denmark	89.8	479 479	8.4	45 925	10
Greece	104.3	998 167	13.7	148 440	15
Ireland	26.6	115 710	3.1	12 851	11
Netherlands	48.4	760 133	6.5	101 685	13
Norway	70.5	319 140	9.2	42 988	13
England	110.6	5 755 936	9.5	497 033	9
Wales	79.4	153 490	6.6	12 796	8

admissions if the sample is representative. A potential difficulty in carrying out the calculations is the possibility of missing data on more severely injured patients. Those working in EDs will recognise this phenomenon where severely injured patients are whisked rapidly through the ED to intensive care or surgery without much preliminary data collection. The ability and practice of retrospectively collecting data may vary considerably between hospitals and countries. In this, the incidence of hospital admissions from the ED data extrapolated to national coverage was compared with the incidence of injury hospitalisation measured from the HDR data.

Results

Table 2.3 shows the baseline number and incidence per 1000 cases attending emergency departments for all cases and those comprising SRVFs by country. The direct method of standardisation was used with the total population of the participating countries as the reference population. The table shows a four-fold variation in attendance rates between countries and a threefold variation in the proportion of attendances due to SRVFs.

Table 2.4 shows the results of this comparison for the five countries, which had comparable data for home, leisure, and occupational injuries (all unintentional injuries minus road injuries) in both ED and HDR systems. There is considerable variability in injury admission rates but with the exception of Ireland extrapolated and measured rates are similar.

Table 2.4 National coverage of the ED surveillance system and incidence of admitted injury patients as measured by extrapolation from the ED system and HDR system

Country	Coverage of ED surveillance (%)	Extrapolated annual national incidence 1	Actual annual incidence 2
Austria	2	19.3	18.8
Ireland	7	2.9	8.9
Netherlands	15	3.5	3.7
England	5	5.4	6.4
Wales	61	7.1	8.4

[1] Per 1000 population of admissions from ED surveillance.

[2] Admissions per 1000 population from the HDR system.

Discussion

Large international differences in reported injury incidence between countries can be due to variations in the true incidence of injuries or to the profile of injuries seen in EDs or admitted to hospital. The work carried out in this study suggests that the use of more considered methods of comparing data between countries will lead to less biased results. We have suggested two methodological refinements to help with this work: the use of SRVFs, and measurement of the representation of national extrapolation from ED sample data.

The development of SRVFs as an ED based injury indicator required specifying which fractures should be included or excluded and we defined our indicator on the basis of exclusions. Our rationale for the exclusion of specific groups or individual fractures is as follows: fracture of facial bones; a high proportion of facial bone fractures are nasal fractures and many hospitals do not X-ray these, so they may not be recorded; vertebral column fractures; this group contains many fractures which may not be identified and or be significant injuries. The median length of stay for this group varied from 4-7 days across the eight countries providing HDR data. It is clear that the vast majority of these patients will have fractured transverse processes or osteoporotic wedge fractures and not life threatening spinal fractures requiring immobilization or surgery. There will be very considerable variation in the proportions X-rayed in these groups between health care administrations; fracture of clavicle and scapula; many clinicians do not X-ray all suspected clavicular fractures, particularly if there is no gross displacement.
The exclusion of wrist fractures under the age of five reflects the frequent occurrence of greenstick fractures below this age, many of which will not attend for X-ray. Clinicians are well used to toddlers with podgy arms removing immobilisation splints and plasters after a day or two and using their injured arm normally and apparently without pain. It is logical to assume that many others may never attend for diagnosis.

The use of SRVFs can help understand inter-country variability. For instance, Austria has a high prevalence and proportion of SRVFs but a low prevalence of all injury attendances indicating that the ED system deals with higher levels of injury severity on average and that more minor injuries are treated elsewhere or self treated. Later, in table 2.4, the high incidence of fractures in Austria is reflected in a high hospital admission rate. For most of the other countries there is less variability in the proportion and incidence of SRVFs than for all ED attendances. Whilst this initial analysis provides some evidence of face and content validity for SRVFs, further research is required to test other aspects of validity and reliability of this group of fractures as a robust injury indicator.

The analysis of the effect of estimating national incidence from sample data also assisted with the interpretation. The results for the comparison of extrapolated and actual incidences of hospital admissions for injuries show that the rates were broadly similar for four of the five countries. There was particularly good agreement between the two sources of data in Austria and the Netherlands. For Ireland, there was a marked discrepancy that is due to the fact that only two hospitals participate in the ED surveillance system and clearly the catchment population for these hospitals is not representative of the entire country. For both England and Wales, the ED extrapolations underestimated the hospital admission rates by around 15%. This is not a gross degree of error and, in part, can be expected to arise from the mechanism of recording in-patient data in both these countries. At the time of data collection, neither country was able to link the consultant episodes of care which form the basis of individual computerised records to produce individual person-based records, which make up an entire hospital spell, culminating in a discharge or death and adjusting for transfers between hospitals. This means the HDR data may be inflated by around 8% [10]. However, it is also possible that ED estimates of admitted patients are biased downwards when admissions are postponed. This can occur when patients are referred from ED to specialist clinics and then a decision is taken to admit patients from the specialist clinic. These admissions will not be recorded in the ED data.

The calculation of injury incidence data from hospitalisation records is not a trivial or simple issue, with problems caused by the definition of injury, day case admissions, readmissions, admissions and discharges in different years, missing external cause codes, external cause codes applied to non-injuries and injuries being coded as not the principal diagnosis [11]. Our research design attempted to minimise these factors but some biases will inevitably remain. We used the international classification of disease codes E800 to E999 (ICD, 9th revision) to select and classify injuries, except 'misadventures to patients during surgical and medical care' (ICD-9 E870-876), 'surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure' (ICD-9 E878-879), and 'drugs, medicaments and biological substances causing adverse effects in therapeutic use' (ICD-9 E930-E949). Unintentional injuries (E47-E53), traffic injuries (E470-E474, E479), and intentional

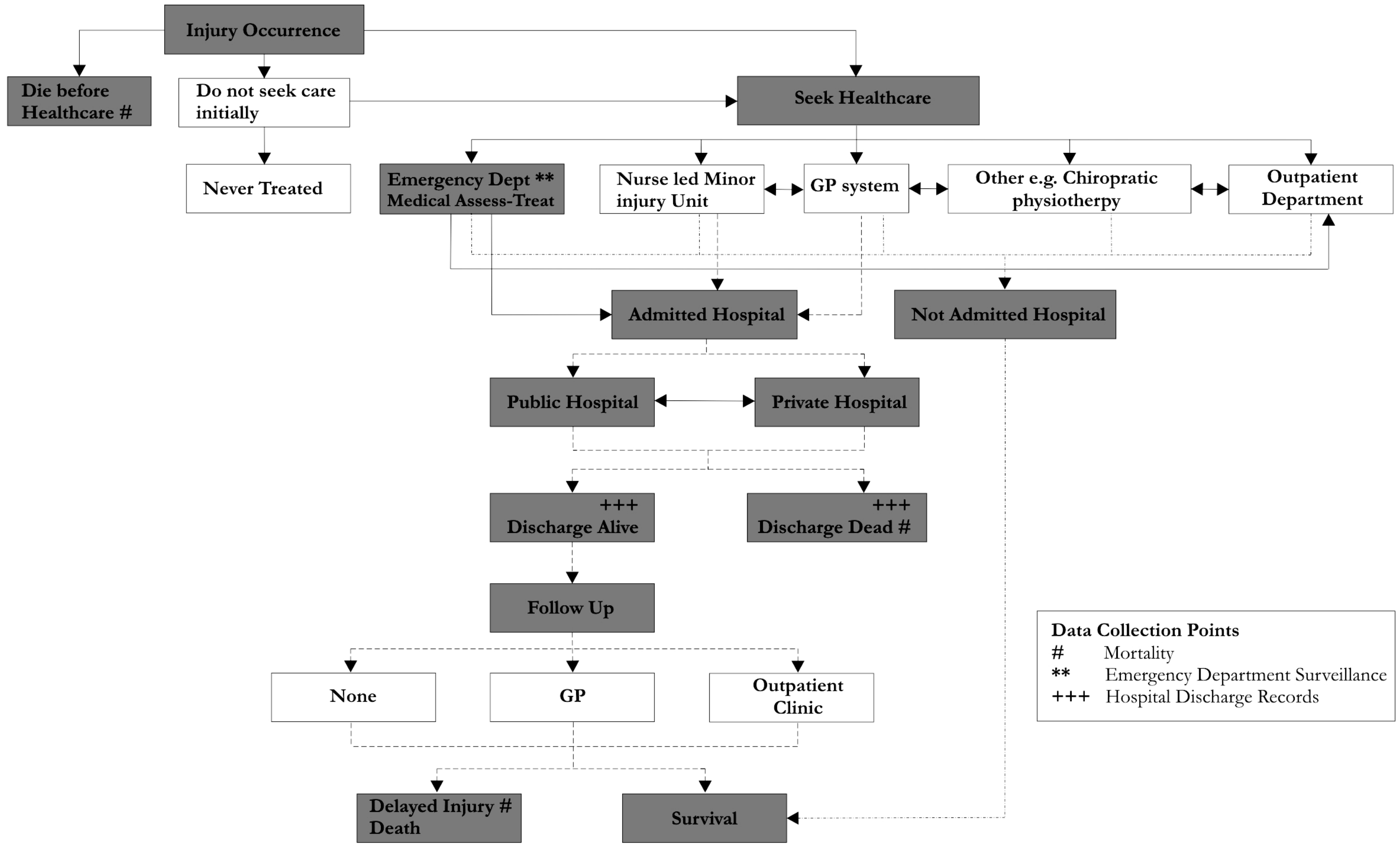


Figure 2.1 Health care flow diagram of acute injury

injuries (E54-E56) were analysed. Day cases and inpatients with length of stay of zero were both classified as day cases, and were excluded from the analyses. Due to the lack of reliable information on re-admissions (these could only be distinguished for three countries), these are included in all analyses as first admissions. However, this is likely to produce a small bias. In New Zealand, readmissions accounted for 9% of injury hospitalisations with most of these occurring within E878-E879 and E929, codes which are excluded from our analyse [11]. The bias produced by comparing people attending ED in a particular year with patients discharged from hospital in that year is also likely to be very small. In the New Zealand study, using discharges overestimated incidence by 0.1% in 1997 [11].

This chapter set out to describe the methodological issues that arose in comparing injury incidence data across countries during the EUROCOST study. We have specified the definitions of injury and groupings of ED injuries to be used to maximise the possibility of comparison of incidence between countries in Europe. A new injury indicator based on ED data, SRVFs, has also been proposed, which looks promising but requires further work on validation. We have also developed a method of testing the validity of national extrapolations from ED sample data and found that in most of the participating countries with available data the extrapolations provide reasonably accurate estimates of the incidence of injuries requiring hospitalisations. These methodological developments will be of interest to a wide audience of injury epidemiologists, prevention practitioners and health economists who need to understand international variations in injury rates.

References

1. Polinder, S., W.J. Meerding, H. Toet, M.E. van Baar, et al., A surveillance based assessment of medical costs of injury in Europe: phase 2. 2004, ErasmusMC and Consumer Safety Institute: http:/www.euroipn.org/grd/attachments/80/final%20report.pdf.
2. Langley, J. and R. Brenner, What is an injury? Injury Prevention, 2004. 10: p. 69-71.
3. World Health Organization, Guidelines for conducting community surveys on injuries and violence. 2004, World Health Organization: Geneva.
4. Cryer, P.C., S.N. Jarvis, P. Edwards, and J.D. Langley, Why the government was right to change the 'Our Healthier Nation' accidental injury target. Public Health, 2000. 114: p. 232-237.
5. Cryer, C., J.D. Langley, S.C. Stephenson, S.N. Jarvis, et al., Measure for measure: the quest for valid indicators of non-fatal injury incidence. Public Health, 2002. 116(5): p. 257-62.
6. Sim, F. and P. Mackie, It were to be wished the flaws were fewer... But the main thing is, does it hold good measure? Public Health, 2002. 116: p. 251.
7. Mulder, S., W.J. Meerding, and E.F. Van Beeck, Setting priorities in injury prevention: the application of an incidence based cost model. Inj Prev, 2002. 8(1): p. 74-8.
8. Lyons, R.A., S.V. Lo, M. Heaven, and B.N.C. Littlepage, Injury surveillance in children - usefullness of a centralised database of accident and emergency attendances. Inj Prev, 1995. 1: p. 173-176.
9. Dessypris, N., E. Petridou, Y. Skalkidis, M. Moustaki, et al., Countrywide estimation of the burden of injuries in Greece: a limited resources approach. Journal of Cancer Epidemiology and Prevention, 2002. 7: p. 123-129.

10. Brophy, S., G. John, E. Evans, and R.A. Lyons, Methodological issues in the identification of hip fractures ensuring routine hospital data: a database study. Osteoporos Int, 2005. in press.
11. Langley, J., S. Stephenson, C. Cryer, and B. Borman, Traps for the unwary in estimating person based injury incidence using hospital discharge data. Inj Prev, 2002. 8(4): p. 332-7.

Appendix 2.A EUROCOST data set definition of injury groups: definition of injury groups according to European Home and Leisure Accident Surveillance System (EHLASS 2000), ICD9 and ICD10 codes

Injury group	EHLASS[1] Codebook		ICD-9CM	ICD-10
	Type of injury	Part of body injured		
Head				
1. Concussion	1	10	850	S06.0
2. Other skull-brain injury	2, 5, 8-9, 11	10, 11	800-801, 803-804, 851-854, 950-951	S02.0-1, S02.7, S02.9, S06.1-9, S04.0-9, S07.1-9, T02.0, T04.0
3. Open wound head	4	11, 12	873.0, 873.1	S01.0, S08.0
Face				
4. Eye injury	1-99	13	870-871, 918	S01.1, S05.0-9
5. Fracture facial bones	5, 6	14, 16	802	S02.2-6, S02.8
6. Open wound face	4	14, 16, 18, 19	872, 873.2-9	S01.1-9, S08.1-9, S09.2
Vertebrae/Spine				
7. Fractures/dislocations/ sprain/strain	5-7	23, 32 42	805, 839.0-5, 846, 847.1-9	S12.0-7, S12.9, S13.0-3, S13.6, S22.0-1, S23.0-1, S23.3, S29.0, S32.0-2, S33.0-2, S33.5-7, T02.1, T03.0-1, T08, T09.2
8. Whiplash/neck	7, 99	29	847.0	S13.4
9. Spinal cord injury	8	23, 32 42	806, 952	S14.0-1, S24.0-1, S34.0-1, S34.3, T06.1, T09.3
Abdomen/Thorax				
10. Internal organ injuries	1-99	33, 34, 41	860-869, 900-902, 926, 929	S26.0-9, S27.0-9, S29.7, S36.0-9, S37.0-9, S39.6-9, T06.5
11. Fracture rib/sternum upper extremity	5	31, 38-39	807.0-3, 809	S22.2-4, S22.8-9
12. Fracture of clavicle/scapula	5	50-51	810-811	S42.0-1, S42.7-9
13. Fracture of upper arm	5	52	812.0-3	S42.2-3
14. Fracture of elbow/forearm	5	53-54	812.4-5,813.0-3, 813.8-9	S42.4, S52.0-4, S52.7-9
15. Fracture of wrist (incl. carpal bones)	5	55	813.4-5, 814	S52.5-6, S62.0-1
16. Fracture of hand/fingers	5	56-57	815-817	S62.2-8
17. Dislocation/sprain/strain shoulder/elbow	6-7	51, 53	831-832, 840-841	S43.0-7, S53.0-4

Injury group	EHLASS[1] Codebook		ICD-9CM	ICD-10
	Type of injury	Part of body injured		
18. Dislocation/sprain/ strain wrist/hand/fingers	6-7	55-57	833-834, 842	S63.0-7
19. Injury of nerves	8	50-59	953.0-1, 953.4, 955	S14.2-4, S24.2, S44, S54, S64, T11.3
20. Complex soft tissue injury	9-12	50-59	880.2, 881.2, 882.2, 883.2, 884.2, 885-887, 903, 927	S45-S49, S55-S59, S65-S69, T04.2, T05.0-2, T11.4-9
Lower extremity				
21. Fracture of pelvis	5	44	808	S32.3-8
22. Fracture of hip	5	60	820	S72.0-2
23. Fracture of femur shaft	5	61	821.0-1	S72.3, S72.7-9
24. Fracture of knee/lower leg	5	62-63	821.2-3, 822, 823	S72.4, S82.0-2, S82.4, S82.7-9
25. Fracture of ankle	5	64	824	S82.3, S82.5-6
26. Fracture of foot (exc. ankle)	5	65-66	825, 826	S92.0-9
27. Dislocation/ sprain/strain knee	6-7	62	836, 844	S83.0-7
28. Dislocation/ sprain /strain ankle /foot	6-7	64-66	837-838, 845	S93.0-9
29. Dislocation/ sprain/strain hip	6-7	60	835, 843	S73.0-1
30. Injury of nerves	8	60-69	953.2-3, 953.5, 956	S34.2-8, S74, S84, S94, T13.3
31. Complex soft tissue injury	9-12	60-69	890.2, 891.2, 892.2, 893.2, 894.2, 895-897, 904, 928	S15.1, S75-S79, S85-S89, S95-S99, T04.3, T05.3-5, T06.3, T13.4-9, T14.5
Minor external				
32. Superficial injury (incl. contusions) make distinction between contusions (2) and abrasions	2-3	12-20,28-31, 38-40,43-99	910-917, 919-924	S00,S10, S20, S30, S40,S50, S60,S70, S80,S90, T00,T09.0, T11.0, T13.0,T14.0

Injury group	EHLASS[1] Codebook		ICD-9CM	ICD-10
	Type of injury	Part of body injured		
33. Open wounds	4	28-31, 38-40, 43-99	874-884 (excl. 880.2, 881.2, 882.2, 883.2, 884.2), 890-894 (excl. 890.2, 891.2, 892.2, 893.2, 894.2)	S11, S21, S31, S41, S51, S61, S71, S81, S91, T01
34. Burns	14-15	12-20,28-31, 38-40, 43-99	940-949	T20-T32
35. Poisoning	13	10-99	960-989	T36-T65
36. Multi-trauma	--	--	Several combinations	Several combinations
Other injuries				
37. Foreign body	--	--	930-939	T15-T19
38. No injury after	97	10-99	--	--
39. Other and unspecified injury	All other combinations		807.4-6, 818-819, 827-829, 830, 839.6-9, 848, 953.8-9, 954, 957, 925, 959, 990-995	Other codes
Not included			905-909 (late consequences), 958 (early complications), 996-999 (medical complications)	

[1]EHLASS codebook 2000

3

International variation in clinical injury incidence: exploring the performance of indicators based on health care, anatomical and outcome criteria

Suzanne Polinder, Willem Jan Meerding, Ronan A. Lyons, Juanita A. Haagsma,
Hidde Toet, Eleni Th. Petridou, Saakje Mulder, Ed F. van Beeck,
and the EUROCOST reference group
Submitted

Abstract

Objective To analyse international variation in clinical injury incidence, and explore the performance of different injury indicators in cross-country comparisons.

Methods Hospital discharge data of seven European countries (Austria, Denmark, Ireland, Netherlands, Norway, England and Wales) were analysed. We tested existing and newly developed indicators based on (a) health care use, (b) anatomical criteria, or (c) expected health outcome: admissions excluding day-cases (a), hospital stay 4+ (a) and 7+ days (a), (serious) long-bone fractures (b), selected radiological verifiable fractures 'SRVFs' (b), and indicators based on international (Global Burden of Disease) and Dutch disability weights (c). Assessment criteria were reduction in incidence variation and length of stay in hospital, and the association between incidence and mortality rates.

Results Indicators based on health care use led to increased variation in incidence rates. Long bone fractures and SRVFs, and both indicators based on injuries with moderate to high disability showed similar variation in clinical incidence compared to the crude rates, smaller variation in median length of stay in hospital and a good association with mortality rates.

Conclusion No perfect or near perfect indicators of clinical injury incidence exist. For international comparisons, indicators based on disability weights, SRVFs and long bone fractures may be sensible indicators to use, in the absence of a direct measure of anatomical severity.

Introduction

Injuries are a major cause of morbidity and mortality in the industrialized world [1, 2]. Valid data on the occurrence of injuries are therefore needed. Differences in incidence by time periods, person characteristics and geographic region, and the association between incidence and exposure to risks and safety practices may help policy makers to identify controllable determinants and develop preventive interventions. Internationally, disease and injury incidence is often measured with the help of hospital-based data systems. These data can potentially be used as a measure of incidence to examine international differences in 'clinical injury' (i.e. hospital admitted injury) occurrence. However, the observed variation in clinical injury incidence can be disturbed by differences in admission policy and registration practices between countries. This is due to the heterogeneity of injuries admitted to hospital, which may range from mild to very severe trauma. This artificial international variation in clinical injury incidence could be minimized using a severity threshold for the case definition [3]. Several indicators have been proposed recently [3-8], but a debate remains around the appropriateness of indicators for measuring the occurrence of injuries using administrative datasets. The proposed indicators have not previously been subject to a comparative analysis using international data.

This chapter aims to contribute to the development and validation of injury indicators by applying previously proposed and newly developed injury indicators to clinical injury incidence data across seven northwest European countries. We used predefined assessment criteria to explore whether variation in clinical injury incidence between countries could be real (i.e. based on variation in injury occurrence) rather than artificial (i.e. based on variation in registration and health care practice).

We have addressed the following questions: a) does clinical injury incidence vary between countries, using different indicators, based on either health care, anatomical or outcome criteria?, b) which indicator results in the lowest variation in clinical incidence, and the lowest variation in length of stay in hospital?, and c) which indicator results in the best association between clinical incidence and mortality rates?

Materials and methods

Data sources

Within the framework of an international project (EUROCOST), we collected hospital admission data for the year 1999 to produce estimates of the incidence and costs of injuries [9]. Data from the following northwest European countries were analysed: Austria, Denmark, Ireland, Netherlands, Norway, UK England, and UK Wales. These seven countries were selected because they could provide Hospital Discharge Register (HDR) data as primary data sources to estimate injury incidence of admitted patients (= clinical injury incidence) for intentional and unintentional injuries. All countries had complete

HDR system coverage, except Ireland where 95% of the hospitals contribute to the HDR.

Injury definition and classification

We applied a uniform case definition to the hospital admission data in accordance with previous studies [10-12]. Only patients with an injury as principal diagnosis were included (ICD-9 800-995, ICD-10 S00-T78) [13]. We excluded patients with an injury due to medical adverse events (ICD-9 E996-999, ICD-10 T80-T88), early complications (ICD-9 E958, ICD-10 T79) or late effects of injury (ICD-9 905-909, ICD-10 T90-T98). Injuries were classified by location and type into 39 groups after consultations with experts in traumatology, orthopaedics, and rehabilitation, to represent groups of patients that have relatively homogeneous health care consumption [14]. The ICD codes for these categories were presented in chapter 2 [15]. For most participating countries no distinction could be made between first admissions and readmissions. Readmissions are therefore included in all the analyses

Calculations

Incidence rates were standardized by age (18 groups) and sex, using the direct method of standardisation. The total population of the participating countries was used as the reference population. The results are also shown as comparative morbidity figures (CMF). The CMF is calculated by dividing the expected number of injured persons incidence rate (age-specific incidence rates of the country multiplied with population numbers of the standard population) by the observed number of injured persons of the country. A coefficient of variation was calculated as the ratio of the unweighted standard deviation to the unweighted mean of the outcome measure.

Severity thresholds / case definitions

We applied several indicators for clinical incidence of injury, based on:
(a) health care criteria (health care use);
(b) anatomical criteria (location and type of injury);
(c) outcome criteria (expected level of disability).
In Appendix 3.A an overview is given of the inclusions of injury groups per injury indicator. We selected indicators that were applicable to the national administrative hospital databases of the participating countries. These databases provided no opportunities to calculate established injury severity measures, such as AIS/ISS or ICISS. Our explorative analysis therefore focuses on proxy measures that could be used in the absence of a direct measure of anatomical injury severity.

<u>a) Health care criteria</u>
1. exclusion of day cases (new indicator).

In the literature [5] it is argued that when day cases are not excluded, biases in estimates of clinical incidence will occur. Day cases and inpatients with length of stay of zero were both classified as a day patient. We tested the performance of a simple new indicator (i.e. all hospital admissions minus day cases).

2. injuries requiring a hospital stay of 4 days or more ('UK White Paper') [16].
3. injuries requiring a hospital stay of 7 days or more (new indicator).

   Our hypothesis was that variation in hospital inpatient rates reduces using higher length of stay thresholds (4+ and 7+ days).

b) Anatomical criteria

4. Selected radiological verifiable fractures 'SRVFs' (new indicator) [15].

   SRVFs include fractures that have radiological verification according to standard practice, and use of this indicator should reduce variation related to the process of data collection and coding [15]. The SRVFs indicator has in fact been defined for the comparison of incidence rates of fractures treated at the Emergency Department rather than the incidence of hospitalisations. However, since hospital admission rates due to SRVFs are high, it seems reasonable to examine the performance of this indicator for the comparability of clinical incidence. At a ProFaNe (Prevention of Falls Network Europe) meeting in 2003 this indicator was advocated for the measurement and evaluation of falls related injury in older people [17].

5/6. Serious long-bone fractures (Cryer) [7] and long-bone fractures (new indicator).

   Long-bone fractures were defined as cases admitted to hospital with primary diagnosis of fracture of the femur, or fractures of other long bones of the upper and lower limbs that require an operative procedure. The need for an operative procedure has been proposed as a proxy measure of abbreviated injury scale (AIS), severity score of three or greater) [6]. We used length of stay in hospital as a proxy for injury severity, since no AIS and /or Injury Severity Score (ISS) information was available in our data. McClure suggested that an indicator using 9+ days stay was optimal in terms of sensitivity and specificity when using a threshold of ISS> 15 as the definition of a case of serious injury [6]. We followed this suggestion and defined 'serious long bone fractures' as long bone fractures with hospital duration of nine days or more. In addition, we tested the performance of the more simple potential new indicator 'long bone fractures', which made no prior exclusions by length of stay.

c) Outcome criteria

7. Injuries with moderate to high disability weight (Global Burden of Disease) [18].

   The Global Burden of Disease (GBD) study [1, 18] provided disability weights by nature of injury using the person-trade-off method. Participants were asked to trade-off absolute numbers of healthy individuals against absolute numbers of individuals in a given suboptimal health state. Disability weights provide a summary measure of the severity of the expected health consequences of diseases and injury. This indicator includes injuries with a moderate to high disability weight according to the GBD study, defined as a disability weight for treated forms of sequelae higher than 0.20.

8. Injuries with moderate to high disability weight (Dutch study).
   A Dutch study (IBIS) provided disability weights by type of injury representing the severity of the health state following injury in survivors. These weights were derived using the time-trade-off method (TTO) and the visual analogue scale (VAS). In the TTO, participants were asked how much time they were willing to trade in order to be restored from the presented health state to full health. With the VAS the participants scored the health states on a vertical thermometer graded from 0 (worst imaginable health state) to 100 (best imaginable health state). Subsequently, the VAS and TTO values were transformed into disability weights. The assumption is made that the Dutch disability weights were applicable for the other participating countries. We selected injuries with a moderate to high disability weight, defined as a disability weight higher than 0.10.

Assessment criteria

We assessed each of these indicators according to the following criteria:

1. Reduction in the international variation in clinical incidence (as measured by the coefficient of variation).
2. Reduction in the international variation in median length of hospital stay. This assessment criterion was not applied to the health care criteria.
3. Comparable ranking of countries according to the clinical incidence rates and according to mortality. The injury related mortality rates are based on the World Health Organization Statistics [19].

We hypothesized that when the case definition was restricted to injury groups with a severity threshold indicating a necessity for hospital admission that international variation in clinical incidence and hospital length of stay would reduce. Also, assuming more or less similar quality of care and case fatality rates in northwest European countries and a distribution of exposures producing a similar distribution of injury severity then, clinical incidence rates would be more strongly associated with mortality rates.

Results

Crude data

The age-standardized clinical incidence varied substantially using crude data, ranging from 6.6 to 22.9 per 1,000 person years (Table 3.1). Austria ranked highest, followed by Denmark, Wales, Ireland, Norway, England, and the Netherlands.

Table 3.1 Clinical injury incidence (per 1,000) and CMF for injury indicators based on health care criteria (assessment criteria 1)

	Crude data		**Excluding day cases**		**Hospital stay > 4 days**		**Hospital stay > 7 days**	
	Incidence	**CMF**	**Incidence**	**CMF**	**Incidence**	**CMF**	**Incidence**	**CMF**
Austria	22.9	1.5	21.7	1.8	11.1	2.4	6.6	2.2
Denmark	18.1	1.2	15.4	1.3	6.9	1.5	4.6	1.5
Wales	16.0	1.1	12.3	1.0	4.1	0.9	2.7	0.9
Ireland	15.5	1.0	12.5	1.0	3.6	0.8	2.8	0.9
Norway	14.7	1.0	12.9	1.1	4.8	1.0	2.9	0.9
England	11.9	0.8	9.1	0.8	3.1	0.7	2.1	0.7
Netherlands	6.6	0.4	5.2	0.4	2.8	0.6	2.0	0.7
Coefficient of variation	0.34		0.40		0.56		0.48	

Injury incidence indicators

Health care criteria

The clinical incidence data from most countries included about 20% day cases, but were lower in Austria (5%), Norway (12%) and Denmark (15%). Excluding day cases in the analysis resulted in larger variation of injury incidence between the countries, which is shown by and increased coefficient of variation (Table 3.1).

When patients with a length of stay shorter than four or seven days were excluded, this also resulted in an increased variation of clinical incidence (Table 3.1). For Wales, Ireland, Norway, England, and the Netherlands the clinical incidence rate for long stay admitted injury patients (hospital stay > 7 days) varied between 2.0 and 2.7 per 1,000 inhabitants. Only in Denmark (4.6) and Austria (6.6) substantially more patients were admitted after an injury for longer than a week. Comparing the clinical incidence rates of indicator 3 (hospital stay > 7 days) with the mortality ranking Austria and Denmark also demonstrated the highest mortality rates (Figure 3.1). Mortality in Norway, however, was almost twice as high as in the Netherlands, England and Wales, whereas the clinical incidence rates of indicator 3 (hospital stay > 7 days) were low for all these four countries.

Anatomical criteria

All indicators based on anatomical criteria resulted in reduced or similar variation in clinical incidence (Table 3.2) and reduced variation in median length of stay in hospital as opposed to the crude data (Table 3.4). The median length of stay of patients admitted with serious long bone fractures is quite comparable across countries.

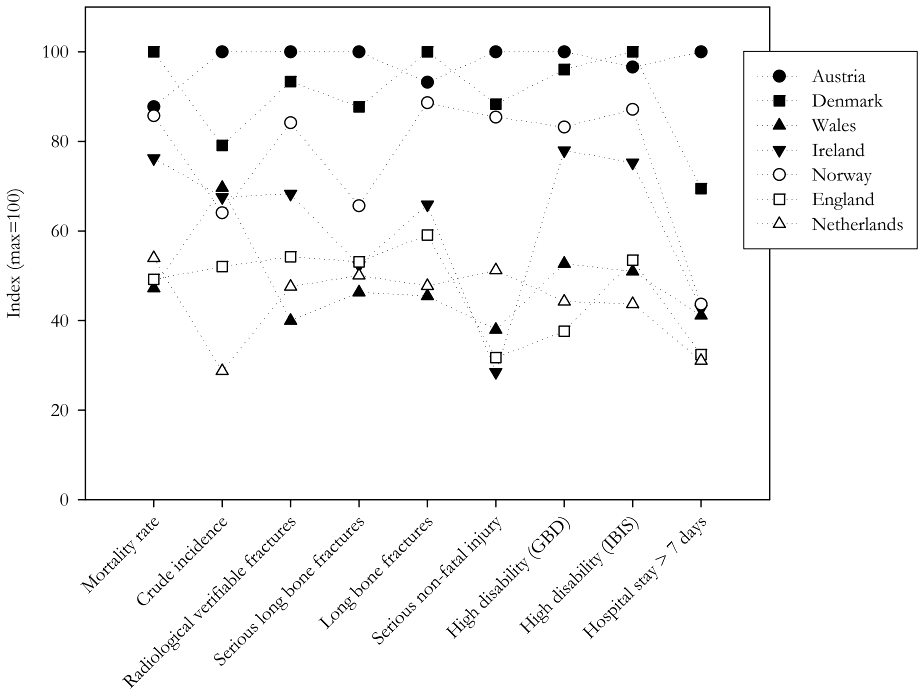


Figure 3.1 Country ranking according to the clinical incidence rates and mortality by injury indicators (assessment criteria 3)

Contrary to the crude data, indicators based on anatomical criteria showed reasonable (serious long bone fractures) to good (SRVF and long bone fractures) associations with mortality rates (Figure 3.1). For SRVF and long bone fractures an almost similar and consistent pattern of international variation in clinical incidence was observed. Higher than average incidence rates were found for Austria, Denmark, Norway and Ireland, whereas incidence rates on or below the average were observed for England, Wales, and the Netherlands. Norway ranked consistently higher and Wales ranked consistently lower compared to the crude incidence ranking, which corresponds with the mortality ranking (Figure 3.1). The coefficient of variation of the indicators based on anatomical criteria (0.31-0.34) was almost equal to the coefficient of variation of the mortality rates (0.29, data not shown).

<u>Outcome criteria</u>

The indicators based on expected levels of disability resulted in a slightly increased variation in clinical incidence for the GBD weighting scale, whereas the Dutch disability weight showed a somewhat lower variation in clinical injury incidence than the crude data (Table 3.3).

Table 3.2 Clinical injury incidence (per 1,000 inhabitants) and CMF for the indicators based on anatomical criteria (assessment criteria 1)

	Crude data		Radiological verifiable fractures		Serious long bone fractures		Long bone fractures	
	Incidence	**CMF**	**Incidence**	**CMF**	**Incidence**	**CMF**	**Incidence**	**CMF**
Austria	22.9	1.5	5.5	1.9	2.6	1.8	4.1	1.7
Denmark	18.1	1.2	5.2	1.7	2.3	1.6	4.4	1.8
Wales	16.0	1.1	2.2	0.7	1.2	0.8	2.0	0.8
Ireland	15.5	1.0	3.8	1.3	1.4	0.9	2.9	1.1
Norway	14.7	1.0	4.7	1.6	1.7	1.2	3.9	1.6
England	11.9	0.8	3.0	1.0	1.4	1.0	2.6	1.0
Netherlands	6.6	0.4	2.6	0.9	1.3	0.9	2.1	0.9
Coefficient of variation	0.34		0.34		0.32		0.32	

Injuries with a moderate to high disability weight showed less variable hospital durations than the total population on both indicators (Table 3.4). For the disability indicators the same dichotomy arises as was found for the anatomical criteria, with 1½-2 times higher incidence rates for Austria, Denmark and Norway, and Ireland compared with Wales, England and the Netherlands. Using injury indicators based on disability, Norway ranked consistently higher and Wales ranked consistently lower compared to the crude incidence ranking. Both disability indicators show a quite comparable clinical incidence pattern compared to the mortality ranking (Figure 3.1).

Discussion

This chapter described four previously proposed and four new injury indicators and explored their validity with use of three assessment criteria. Indicators based on health care criteria led to increased international variation in incidence rates and a different pattern of international variation compared to mortality rates. The anatomical indicators (serious) long bone fractures and SRVFs, as well as both indicators based on expected disability did not result in a substantial reduction of the variation in clinical incidence. However, they were associated with reduced variation in median length of stay in hospital and showed fair to good associations with mortality rates. Whatever measure is used, international differences in clinical incidence of injuries of moderate to high severity remain considerable, and are higher than international differences in injury mortality.

Table 3.3 Clinical injury incidence (per 1,000 inhabitants) and CMF, injury indicator based on outcome criteria (assessment criteria 1)

	Crude data		High disability (GBD)		High disability (IBIS)	
	Incidence	CMF	Incidence	CMF	Incidence	CMF
Austria	22.9	1.5	4.7	1.7	4.0	1.6
Denmark	18.1	1.2	4.6	1.6	4.1	1.7
Wales	16.0	1.1	2.5	0.9	2.1	0.9
Ireland	15.5	1.0	3.7	1.3	3.1	1.2
Norway	14.7	1.0	3.9	1.4	3.6	1.5
England	11.9	0.8	1.8	0.6	2.2	0.9
Netherlands	6.6	0.4	2.1	0.7	1.8	0.7
Coefficient of variation	0.34		0.36		0.32	

Indicators based on health care criteria

In earlier research, McClure introduced 'injuries that result in hospitalisation' as an indicator [6]. However, indicators based on hospital admission of any severity or diagnosis are biased and unstable [4]. Indicators based on length of stay in hospital have the disadvantage that they are sensitive to changes due to service factors [4]. Furthermore, since the proportion of day cases was the lowest in the country with the highest incidence (Austria) the international variation of the clinical incidence rate increased when day cases were excluded. In this explorative study, the indicators based on health care criteria led to increased variation in clinical incidence rates, which supports earlier recommendations to avoid their use.

Indicators based on anatomical criteria

Since differences in performance between serious long bone fractures and long bone fractures were not substantial, we prefer the less complex indicator, i.e. long bone fractures. However, the main disadvantage of (serious) long bone fracture is that it is only useful as an indicator for serious extremity injury, whereas it fails to consider important mortality and disability causing injuries, such as skull-brain, and spinal cord injury. The indicator SRVFs was developed as an indicator for injuries treated at the ED (and subsequently admitted or not). It therefore includes injuries that are not necessarily severe, and would not be treated as in-patients in most countries. Examples are fractures of wrist and lower leg. However, both SRVFs and 'long bone fractures' satisfied two of our assessment criteria and are therefore recommended for further research and application if direct measures of anatomical severity cannot be obtained.

Table 3.4 Median length of stay (days) by injury indicators based on anatomical and outcome indicators (assessment criteria 2)

	Crude data	SRVF	Serious long bone fractures	Long bone fractures	High disability (GBD)	High disability (IBIS)
Austria	4	9	16	10	9	10
Denmark	2	6	15	7	6	7
Ireland	2	4	13	4	4	4
Netherlands	2	8	16	9	10	11
Norway	2	5	12	5	5	5
England	1	7	14	8	7	7
Wales	1	10	15	10	8	9
Coefficient of variation	0.50	0.31	0.10	0.31	0.31	0.34

Indicators based on outcome criteria

We introduced new indicators based on disability weights and showed them to be a possible alternative for indicators based on anatomical criteria. For injuries with a moderate to high disability weight the variation in clinical incidence and the variation in hospital duration were similar to the variation using crude data. However, variation in length of stay in hospital was reduced, and these indicators showed a similar pattern of variation as with mortality rates. Further refinement and testing of these new indicators is therefore recommended.

Strengths and weaknesses of the study

To our knowledge, this is the first study in which existing and newly developed injury indicators were all together empirically tested with hospital admission data of seven North-West European countries. This demonstrates that it is feasible to apply these indicators to routinely collected data. Nevertheless, our explorative study has several limitations and further work is necessary to validate and improve injury indicators.

The use of routinely available administrative national data systems bears some weaknesses. First of all, the quality of recording, coding and classifying injuries may differ between countries. For example, several of our comparisons used specific selections of injury diagnoses, assuming comparability of injury type and severity between countries for those selections. Differential misclassification within the administrative databases between countries may have occurred and affected the results of our comparisons of both clinical incidence rates and median length of stay in hospital. International differences in data quality can compromise attempts to standardize injury indicators but can only be identified with the help of in-dept research. Therefore, additional validation studies are recommended, with samples of hospitalised injury data from several countries being selected and judged by an expert panel.

Our comparison of clinical incidence rates with mortality rates also has limitations, since the case fatality rate of injury could vary between countries. The absence of empirical data makes this assumption difficult to prove or disprove. However, by focusing on a rather homogeneous set of countries in North-Western Europe, we think this problem has probably largely been avoided in our study. Nevertheless, additional study of variation in clinical case fatality rates for specific selections of injuries, which could not be conducted with the available data, is recommended. In our explorative analysis of indicators we used several proxies for severity, duration of hospitalisation, type of injury, and expected level of disability. In the data available to us, it was not possible to define an injury severity threshold using a metric such as the Abbreviated Injury Scale (AIS). The availability of adequate data on direct anatomical measures of injury severity in (national) databases could further enhance international data comparability and would make the injury indicators more useful for policy making, especially with regard to injuries of higher severity levels. With this purpose in mind Cryer and colleagues developed the 'age-standardised serious non-fatal injury' indicator [10]. This indicator is based on ICISS scores, i.e. it is a threat-to-life severity scale based on crude in-hospital mortality rates by ICD-code [20]. In principle, this indicator is applicable to ICD-based administrative databases. However, since the participating countries in our study did not provide individually specified ICD-codes we could not exactly distinguish ICD-10 and ICD-9 principle diagnoses by the ICISS severity threshold and could not test the performance of this indicator against our assessment criteria.

Recommendations

Our study must be interpreted as an exploration of the performance of injury indicators in an international perspective. For the further validation of specific injury indicators we recommend using larger samples of injury patients from more regions within countries, to increase the power and validity of the results.

Nevertheless, the observed effects for various case selection criteria serve as a warning for undertaking international comparisons of clinical incidence of injury. Our findings question the feasibility of comparing comprehensive and therefore heterogeneous injury populations in trend analyses or international comparisons. In particular hospital admission rates for minor injuries are influenced by large differences in registration practice and health care policy. In order to reduce these methodological problems it is better to focus on the more severe injuries. However, the choice of indicator of injury occurrence has a substantial influence on international comparisons and no perfect or near perfect indicators have yet been developed. Indicators based on disability weights or on anatomical criteria satisfied two of our three assessment criteria. If we assume that indicators should focus attention on important problems [4], then indicators based on disability weights (GBD and Dutch weights) may be sensible indicators to use, in the absence of a direct measure of anatomical severity. The long bone fractures indicator performs quite well, but has the disadvantage that it does not include some important injuries with a high burden in terms of mortality and disability. The same argument applies to the SRVFs indicator, which was not developed for this purpose but for counting ED-treated injury patients [15]. The choice of indicator will depend on the specific research or policy question addressed. For international comparison of the clinical incidence of home and leisure injuries, the long bone fractures indicator might satisfy, because the impact on health among this group is largely dominated by fractures, particularly in the elderly. For international comparison of the clinical incidence of traffic injuries, a combined indicator based on mortality and disability weights might be preferable, since these indicators also include injuries to the head, spine and internal organs, which are frequently fatal or very disabling for a substantial part of hospital-admitted traffic victims.

We recommend avoiding the naïve use of hospital-based data systems for international comparisons and national trend analyses. The risk of measuring artificial instead of real differences in injury incidence between countries, patient groups, or time periods is large. The methodological considerations and developments recommended in this chapter should be further refined and tested before they can be used as tools for those who need to compare injury incidence data.
Many of the injury indicators of non-fatal injury analysed in this chapter are based on moderately high thresholds of severity. There is merit in considering the development of non-fatal injury indicators that capture less severe cases, but which exclude minor/superficial injury. It should be recognized, that this is not likely to be possible using hospital inpatient data alone [10], since many moderately severe injuries are treated in outpatient settings without recourse to admission to hospital. Further research requires studies utilising linkage of individual level outpatient (and emergency department) and inpatient data with high quality coding and preferably severity measures incorporating both threat to life and threat to disability scales. Data from several ongoing and planned prospective burden of injuries studies should help answer these questions.

References

1. Murray, C.J. and A.D. Lopez, Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. The Lancet, 1997. 349(9063): p. 1436-42.
2. Morrison, A., D.H. Stone, and EURORISC working group, Injury mortality in the European Union 1984-1993. Eur J Public Health, 2000. 10: p. 201-7.
3. Cryer, C., J.D. Langley, S.N. Jarvis, S.G. Mackenzie, et al., Injury outcome indicators: the development of a validation tool. Inj Prev, 2005. 11: p. 53-57.
4. Cryer, C., J.D. Langley, S.C. Stephenson, S.N. Jarvis, et al., Measure for measure: the quest for valid indicators of non-fatal injury incidence. Public Health, 2002. 116(5): p. 257-62.

5. Langley, J., S. Stephenson, C. Cryer, and B. Borman, Traps for the unwary in estimating person based injury incidence using hospital discharge data. Inj Prev, 2002. 8(4): p. 332-7.
6. McClure, R.J., N. Peel, D. Kassulke, and R. Neale, Appropriate indicators for injury control? Public Health, 2002. 116(5): p. 252-6.
7. Cryer, P.C., S.N. Jarvis, P. Edwards, and J.D. Langley, How can we reliably measure the occurrence of non-fatal injury? Int J Consum Prod Saf, 1999. 6(4): p. 183-91.
8. Cryer, C. and J.D. Langley, Developing valid indicators of injury incidence for "all injury". Inj Prev, 2006. 12: p. 202-207.
9. Polinder, S., W.J. Meerding, M.E. van Baar, H. Toet, et al., Cost estimation of injury related hospital admissions in ten European countries. Journal of Trauma, 2005. 59(6): p. 1283-1291.
10. Cryer, C., J. Langley, and S. Stephenson, Developing valid injury outcome indicators: a report for the New Zealand injury prevention strategy, O.R.O. 049, Editor. 2004, Occasional Report OR 049: Dunedin, New Zealand.
11. Langley, J., International comparisons: we need to know a lot more. Inj Prev, 2001. 7(4): p. 267-9.
12. Moustaki, M., M. Lariou, and E. Petridou, Cross country variation of fractures in the childhood population. Is the origin biological or "accidental"? Inj Prev, 2001. 7(1): p. 77.
13. WHO, International Classification of Diseases; 9th edition. 1997, World Health Organisation: Geneva.
14. Meerding, W.J., H. Toet, S. Mulder, E.F. van Beeck, et al., A surveillance based assessment of medical costs of injury in Europe: phase 1. 2002, Consumer Safety Institute: Amsterdam.
15. Lyons, R.A., S. Polinder, C.F. Larsen, S. Mulder, et al., Methodological issues in comparing injury incidence across countries. International Journal of Injury control and Safety Promotion, 2006. 13(2): p. 63-70.
16. Secretary of State for Health, Saving Lives: Our Healthier Nation, in The Stationery Office, T.S. Office, Editor. 1999: London.
17. ProFaNE, http://www.profane.eu.org.
18. Murray, C.J.L. and A.D. Lopez, The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Global Burden of Disease and injury series. 1996, Boston: The Harvard School of Public Health.
19. WHO, World Health Organization mortality database. Available from: http://www3.who.int/whosis/menu.cfm?path=whosis,mort&language=english.
20. Rutledge, R., D.B. Hoyt, A.B. Eastman, M.J. Sise, et al., Comparison of the Injury Severity Score and ICD-9 diagnosis codes as predictors of outcome in injury: analysis of 44,032 patients. J Trauma, 1997. 42(3): p. 477-87; discussion 487-9.

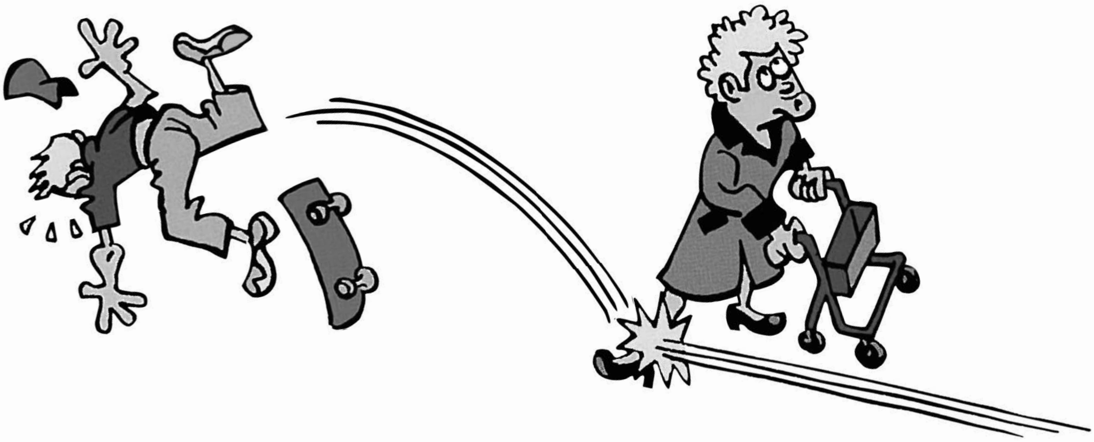
Appendix 3.A Inclusion of injury groups by injury indicator

39 Injury groups	Health care criteria		Anatomical criteria		Outcome criteria	
	Exclusion day cases	Hospital stay > 4/7 days	Radiological verifiable fractures	Long bone fractures	High disability (IBIS)	High disability (GBD)
Head						
1. Concussion	X	X				
2. Skull-brain injury	X	X			X	X
3. Open wound head	X	X				
Face						
4. Eye injury	X	X				X
5. Fracture facial bones	X	X				X
6. Open wound face	X	X				
Vertebrae / Spine						
7. Vertebral column fractures dislocations/sprain/strain	X	X				X
8. Whiplash, neck sprain, distortion of cerval spine	X	X				
9. Spinal cord injury	X	X			X	X
Abdomen / Thorax						
10. Internal organ injury	X	X			X	X
11. Fracture rib / sternum	X	X				
Upper extremity						
12. Fracture of clavicle / scapula	X	X				
13. Fracture of upper arm	X	X	X	X		
14. Fracture of elbow / forearm	X	X	X	X		
15. Fracture of wrist (incl. carpal bones)	X	X	X			
16. Fracture of hand/fingers	X	X				
17. Dislocation / sprain / strain shoulder / elbow	X	X				
18. Dislocation / sprain / strain wrist/hand/ fingers	X	X				
19. Injury of nerves	X	X				
20. Complex soft tissue injury upper extremity	X	X			X	
Lower extremity						
21. Fracture of pelvis	X	X	X		X	X
22. Fracture of hip	X	X	X	X	X	X

39 Injury groups	**Health care criteria**		**Anatomical criteria**		**Outcome criteria**	
	Exclusion day cases	**Hospital stay > 4/7 days**	**Radiological verifiable fractures**	**Long bone fractures**	**High disability (IBIS)**	**High disability (GBD)**
23. Fracture of femur shaft	X	X	X	X	X	X
24. Fracture knee/lower leg	X	X	X	X		
25. Fracture of ankle	X	X	X			
26. Fracture of foot	X	X				
27. Dislocation / sprain / strain of knee	X	X				
28. Dislocation / sprain / strain of ankle / foot	X	X				
29. Dislocation / sprain / strain of hip	X	X			X	
30. Injury of nerves	X	X				
31. Complex soft tissue injury lower extremity	X	X			X	X
Minor external						
32. Superficial injury (incl. contusions)	X	X				
33. Open wounds	X	X				
34. Burns	X	X				
35. Poisoning	X	X				
36. Multitrauma	X	X				
Other injuries						
37. Foreign body	X	X				
38. No injury after examination	X	X				
39. Other and unspecified injury	X	X				

Part II

Economic impact of injury



4

Injury incidence, health care consumption and costs of home and leisure injuries in 7 European counties

Willem Jan Meerding, Suzanne Polinder, Ronan A. Lyons, Hidde Toet, Eleni Th. Petridou, Ed F. van Beeck, Saakje Mulder, and the Eurocost reference group

Submitted

Abstract

Background Cross national comparison of Emergency Department (ED) based injury surveillance data and medical costs helps to identify areas where the burden of injury can be reduced. We described the international variation of home and leisure injury incidence, health care consumption, and medical costs, and investigated the causes of this variation.

Methods We analyzed data from ED based injury surveillance systems in Austria, Denmark, Greece, Ireland, the Netherlands, Norway and the UK (England, Wales). These were combined with national hospital discharge data and unit costs of hospital care. The variation in standardized injury incidence, health care consumption and medical costs was analyzed, including the role of measurement bias, trauma policy and health systems characteristics.

Results The highest incidence of home and leisure injuries was observed in England and Greece (111 and 104 per 1000 person years, respectively), and Ireland and Netherlands ranked lowest (27 and 48 per 1000 person years, respectively). The ranking of countries changed when only injuries with an inherent need for ED treatment were considered. The level and cross national variation of incidence of these selected injuries remained high in children and elderly. The highest per capita medical costs of home and leisure injuries were observed in Austria (€53), followed by Denmark (€39), Norway (€34), and Greece (€23). Major constituents of high per capita costs were a high incidence of severe injuries (Austria, Greece), health system and trauma policy characteristics (high admission rates and hospital length of stay in Austria and Norway), and high unit costs of health care (Norway, Denmark). In most countries, older people contribute proportionally more to the health care costs of home and leisure injuries.

Conclusions A high incidence of home and leisure injuries was observed in children and older people with substantial cross national variation. Cross national differences in incidence only partly explain international variation in health care costs of home and leisure injuries. Variation in health system and trauma policy characteristics, as reflected by admission rates, length of stay and unit costs, seems equally important. International comparisons of ED based surveillance data, added with data on health care consumption and medical costs, can provide clues for injury prevention and improving the efficiency of emergency medicine.

Introduction

Injuries lead to significant morbidity and mortality in all global regions. In European countries, the burden of unintentional injuries and intentional injuries is considerable, with particularly high mortality and disability in males of age 20-45 and older females [1, 2]. They lead to high medical costs as well, particularly for hip fractures (falls) in older people, although much variation is observed in per capita costs of hospitalized injuries across OECD countries [3-5].

Next to mortality data [1] and hospital discharge data, surveillance systems running on hospital Emergency Departments (ED) are an important source of information about injuries as a public health problem [6-9]. Together with injuries treated in primary care, these constitute the injury 'pyramid'. Despite continuous debate on the value of ED based surveillance systems [10], they are crucial for identifying high frequency injuries, population groups at excess risk, newly emerging risks, and for monitoring trends and the implementation of prevention programmes [11]. Compared to household surveys, ED based surveillance is also a cost-effective mode of data collection [12].

In practice, ED based surveillance activities are often restricted to national, regional, or even local level [8]. International comparative data on injuries could enable the assessment of cross national variation in injuries, and consequently identify country-specific modifiable risks. For this purpose, these data should ideally be comprehensive, covering all types and causes of injury and population groups. Previous analyses have demonstrated the important policy intelligence function of international comparative epidemiologic data for diseases in general [13], and for specific health problems such as cardiovascular disease [14]. International comparisons of ED-treated injuries may yield important policy information, but have not been conducted so far.

In Europe, data from ED based surveillance systems in different countries are collected into the Injury Database (IDB, formerly EHLASS), including the injury type and external cause, basic demographics, and data on emergency treatment, hospitalisation, and referral. These data are available for home and leisure injuries (HLI) that are treated on the ED, whereas in a subset of countries similar data for other causes are recorded as well.

ED based surveillance systems and hospital discharge registers also provide important data on health care consumption and related medical costs. As mentioned earlier, the consumption of medical care by injury patients is substantial [5]. Because medical costs are the product of the injury frequency and of their severity in terms of health care need, measures for the economic impact of injuries are complementary to measures for their human impact [4].

In this chapter we present data on home and leisure injuries in seven European countries. Health care consumption and medical costs were linked to ED based incidence data using a common framework developed within a European collaborative effort, the EUROCOST project [15]. We aim to demonstrate the international variation of injury incidence, health care consumption, and medical costs, and to investigate the causes of this variation. A second aim was to test whether ED based surveillance data can be used for international comparisons of the health effects and economic impact of injuries. Based on the findings of our research, we have made some suggestions for improvements to be included in further research.

Materials and methods

Study design

We collected injury incidence data from national ED based surveillance systems for the year 1999. Participating countries were Austria, Denmark, Greece, Ireland, the Netherlands, Norway and the UK (England, Wales). Injury incidence data from ED systems were combined with data on hospital admissions and hospital length of stay (LOS) from national hospital discharge registers, and with unit costs of ED visits and hospital days, using a common framework (Figure 4.1). We selected home and leisure injuries, because these were available for all participating countries (Table 4.1). Types of injury were clustered in 39 injury groups, defined by body location and injury type [15]. These 39 injury groups discriminate among injuries with higher or lower health care consumption or disability. Hospital admission rates were calculated by injury group, age, and sex, by dividing the number of admissions from hospital discharge registers through the number of ED visits from ED data. Health care consumption and costs were calculated by multiplying incidence (ED visits), admission rates, hospital LOS, and unit costs (Figure 4.1).

Primary data analysis of ED visits

In all countries ED surveillance data are collected in a sample of hospitals, and coverage rates ranged from 2% in Austria to 61% in Wales (Table 4.1). Registered numbers of injury were extrapolated towards national level with data delivered by the source countries [15]. In Ireland, Greece, the Netherlands, and UK this extrapolation was based on the number of ED visits and hospital admissions recorded in ED systems, as a proportion of ED visits and hospital admissions in national statistics.

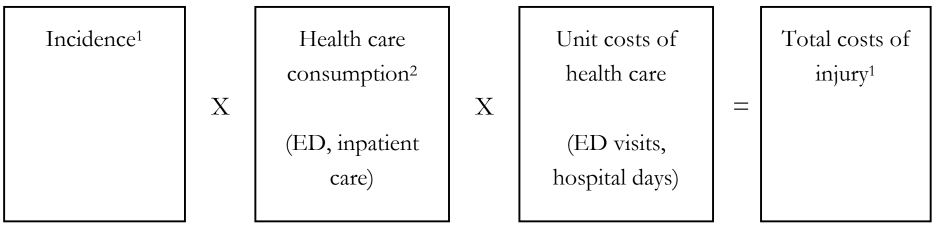


Figure 4.1 Model description

[1] By external cause, type of injury, age and sex.

[2] By type of injury, age and sex

Table 4.1 ED-based injury surveillance systems per country, year 1999

	Name	Number of home and leisure injuries	Population coverage (%)	Validity: other specified or unknown injury (%) [1]	Validity: unknown external cause (%) [2]
Austria	EHLASS	9437	2	4.7	0
Denmark	Injury Register	70431	15	5.6	0
Greece	EDISS	36881	2.2 to 28.9 [3]	0.8	7.9
Ireland	EHLASS	7980	7	11.7	0
Netherlands	LIS	96709	12	2.5	1.8
Norway	Injury Register	15900	4	4.0	2.7
UK-England	HASS / LASS	314704	5	32.1	0
UK-Wales	AWISS	93868	61	15.8	34.7

[1] As percentage of all home and leisure injuries.

[2] As percentage of all registered cases, including other injury categories.

[3] Coverage is 28.9% among children in Athens, and 2.2% among the rest of the population [16].

As for Greece, the overrepresentation of young age groups in the ED surveillance data was accounted for in the analysis [16]. In Austria, Denmark, and Norway, population data by age and sex from the catchment areas of participating hospitals were used to extrapolate ED surveillance data to national level.

The use of ED visits as an indicator of injury incidence in international comparisons may be obstructed by differences in health systems (e.g. role of primary care) and registration practices. This applies particularly to minor injuries, since the patient flow towards the ED may be reduced in case primary care practitioners (e.g. general practitioners, sports physicians) are easily accessible and act as "gatekeepers". Also, registration bias may result in underrepresentation of specific types of injury, such as major trauma patients that are directly transferred to the operation theatre, avoiding registration. To overcome this source of bias, we also defined a subset of injuries, namely selected radiologically verifiable fractures (SRVFs), as described in chapter 2. These are fractures of the upper arm, elbow, fore arm, wrist (except for children < 5 years), pelvis, hip, femur shaft, knee, lower leg, and ankle. SRVFs were chosen as an indicator because these fractures will need ED treatment and follow-up once detected. In the vast majority of cases these will be detected at the ED. Even in systems where general practitioners have direct access to emergency radiology, treatment and follow-up is usually organized through EDs, and hence the event will be captured on ED systems. Because access and organizational issues have a major impact on ED attendance with more minor injuries, variation in attendance with SRVFs across countries should better reflect variations in incidence [17].

Primary data analysis of hospital admissions

For all countries except Greece, hospital discharge data for injuries were derived from registers with a national coverage (for Greece we extracted hospital admission data from the ED surveillance system). All records with a primary diagnosis of ICD-9 800-995 (or equivalent ICD-10 codes) were selected. We used E-code information to exclude injuries due to medical adverse events and late consequences of injuries [18]. Because for only three out of seven countries separate data on hospital readmissions were available (Austria 0.7%; Norway 8.6%; Netherlands 2.6%), readmissions were treated as first admissions in the calculations. Day cases were not counted as hospital admissions, because of large international variation in registration practice. Hospital discharge data were also used to calculate mean lengths of stay (LOS) by patient group.

Demographic standardization

We standardized all outcome variables by age and sex, and used the total EU population in 1999 as standard population (direct standardization) [15].

Primary data analysis of unit costs

We calculated unit costs for ED visits and hospital days, based on local hospital financial statistics that were collected with a structured questionnaire. Unit costs included department costs (including nursing staff and hotel costs), clinical staff, diagnostics, medication, and overhead costs. Costs of surgical operations, research and education (academic hospitals) were excluded. If data on a specific cost item was missing, it was estimated based on the average found in countries with known data on these cost components [15]. All unit costs were adjusted towards the average EU price level with use of purchasing power parities (PPP), to eliminate differences in price level as a cause of international variation in costs of injury [19]. Remaining differences between unit costs should then, in theory, reflect differences in efficiency and the contents of medical care.

Results

In all countries, incidence of ED visits due to home and leisure injuries is highest in young age groups, decreases in adulthood, and increases beyond about age 60 (Figure 4.2a). However, incidence levels vary and there are country-specific patterns. England has the highest overall incidence followed by Greece (111 and 104 per 1000 person years, respectively). All other countries have a much lower incidence, with the lowest found in Ireland and Netherlands (27 and 48 per 1000 person years, respectively). In Greece, incidence increases more steeply with age than in other countries. A low incidence is observed in Ireland across all age groups, but particularly in elderly. However, this could be an artefact due to the low population coverage (2%) of the Irish ED based surveillance system (Table 4.1). Furthermore, the cross national variation in incidence is relatively high in young age groups and the (very) elderly.

When the analysis is limited to selected radiologically verifiable fractures (SRVFs), this reduces the incidence considerably in all countries (Table 4.2), particularly in young and adult age groups (Figures 4.2a, 4.2b). This reflects the observation that the proportion of fractures is much higher in older people than in children and younger adults. Also, the cross national variation in incidence of SRVFs is higher in all age groups, but particularly among children (coefficient of variation increases from 0.38 to 0.56) and persons above age 45 (coefficent of variation increases from 0.32 to 0.57 for age 45-64, and from 0.31 to 0.51 for age 65+). Also the ranking of countries changes, with Austria demonstrating the highest incidence of SRVF (17.3 per 1000), followed by Greece (13.7 per 1000), and England ranking third (9.5 per 1000). The Netherlands and Ireland rank lowest on both types of incidence.

Because total injury incidence is measured by ED visits, the observed variation is partly related to health system characteristics (Table 4.2). England and Denmark demonstrate a high total incidence and a low proportion of SRVFs, suggesting that the threshold for ED treatment is low in these countries. Austria shows an opposite pattern (low total incidence, high proportion SRVF) and seems to have a much higher threshold of injury severity for ED treatment.
There are large differences in health care costs of home and leisure injuries among countries, with highest costs in Austria (€53.0 per capita), followed by Denmark (€38.9 per capita) and Norway (€34.4 per capita) (Table 4.3). Incidence is one constituent of health care costs, with high incidence countries ranking second (Denmark), fourth (Greece), or fifth (England), and low incidence countries ranking seventh (Netherlands)

Table 4.2 Incidence of home and leisure injuries in EU countries, year 1999 (ranked by incidence)[1]

	ED visits per 1000 person years	ED visits SRVFs per 1000 person years	Proportion SRVFs in ED visits (%)
UK – England	110.6	9.5	8.6
Greece	104.3	13.7	13.1
Denmark	89.8	8.4	9.4
UK – Wales	79.4	6.6	8.3
Norway	70.5	9.2	13.0
Austria	59.0	17.3	29.3
Netherlands	48.4	6.5	13.4
Ireland	26.6	3.1	11.7

SRVF: selected radiologically verifiable fractures.
[1] All figures are age- and sex-standardized

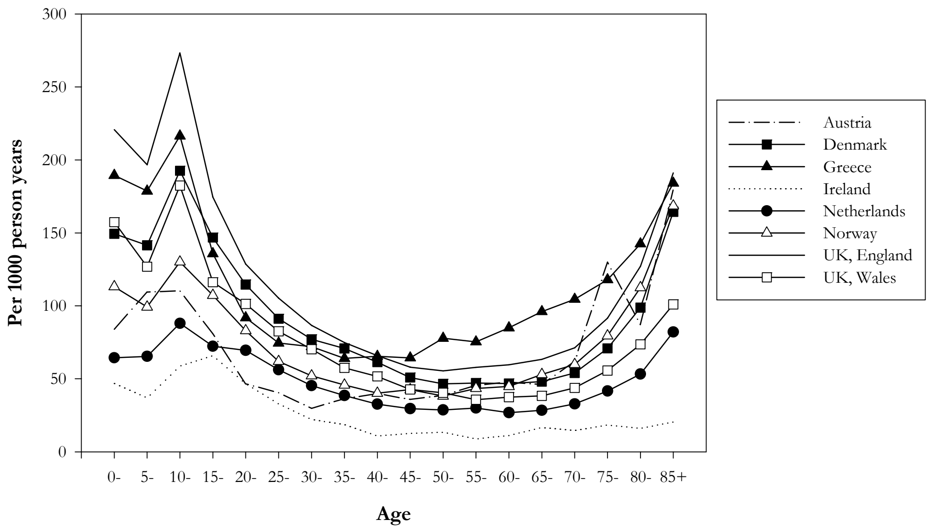


Figure 4.2a ED visits due to home and leisure injuries in 1999 by age and country per 1000 person years: all types of injury

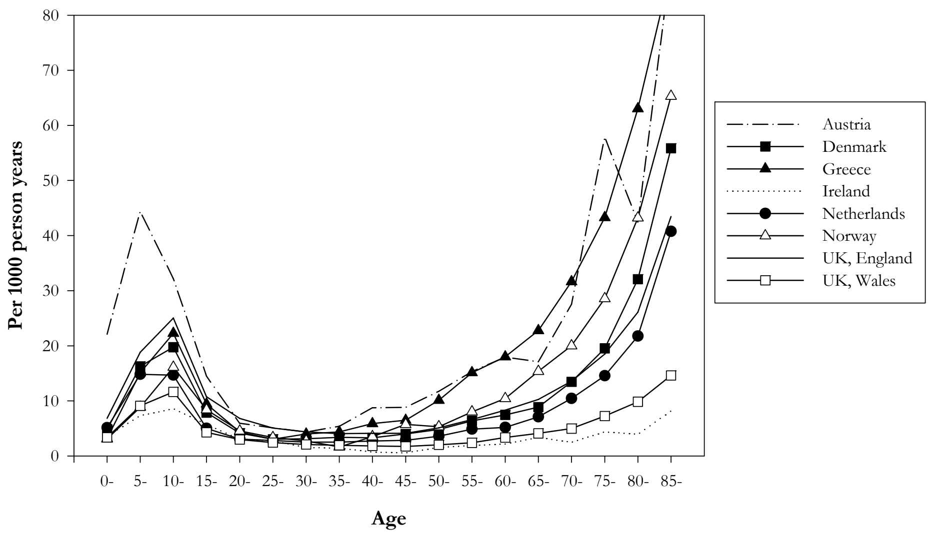


Figure 4.2b ED visits due to of home and leisure injuries in 1999 by age and country per 1000 person years: radiologically verifiable fractures only

Note: Age- and sex-standardized incidence rates per country are listed in table 4.2.

and eight (Ireland). Health system and trauma policy characteristics provide another partial explanation for cost differences. High costs per capita in Austria, Norway, Greece, and Denmark, are also associated with high hospitalization probabilities, particularly when restricted to hospitalization of SRVFs. In addition, Austria demonstrates the highest mean LOS for all injuries (8.2 days) and for SRVF injuries (11.0 days). In countries with a high hospitalization probability, the relative contribution of non-admitted patients to health care costs is low, as expected (Table 4.3, last column). Also the low unit costs of in-hospital days in England, Wales, and Greece contribute to their low ranking in terms of costs, whereas the opposite applies to Norway. Interestingly, injury costs per capita are almost proportionally related to injury costs as a proportion of total health expenditure. This demonstrates that health care costs due to injury are barely associated with the level of total health care expenditures.

As indicated by the costs per capita by age in Figure 4.3, people over the age of 65 contribute proportionately more to the health care costs of injury in all countries, but less so for Ireland, England, and Wales. These exceptions can be explained by the relatively low incidence of home and leisure injuries among older people in these countries (Figures 4.2a and 4.2b). Generally, high costs per capita in older people reflect higher admission probabilities and hospital LOS with age. For instance, despite a low incidence of home and leisure injuries among older people in the Netherlands (Figures 4.2a and 4.2b), this group accounts for a considerable proportion of costs because of a high hospital LOS; also when compared to other countries (data not shown).

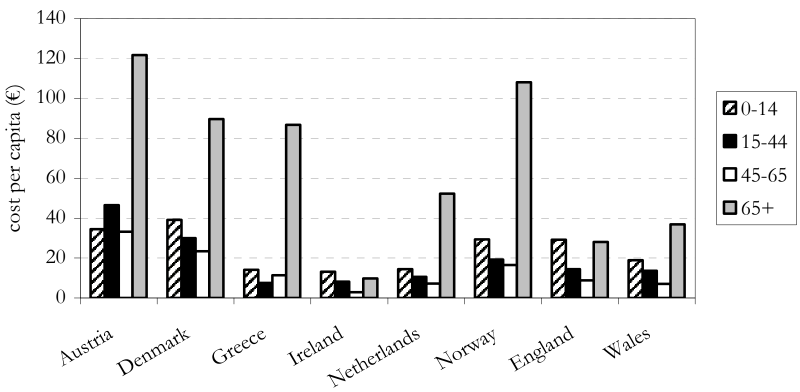


Figure 4.3 Costs per capita for home and leisure injuries by age and country, year 1999

Table 4.3 Incidence, health care consumption and health care costs of home and leisure injuries in EU countries, year 1999 (ranked by total costs per capita) [1]

	ED visits per 1000 person years	Total costs per capita (€)	Hospitalization all injury types (SRVFs only) in %	Mean LOS all injury types (SRVFs only) in days	Costs per hospital day (€)	Mean costs per patient (€)	Proportion of total health expenditure (%)	Costs due to not-admitted patients (%)
Austria	59.0	53.0	32.7 (44.5)	8.2 (11.0)	461	888	3.1	7.2
Denmark	89.8	38.9	6.2 (33.3)	5.8 (7.9)	465	431	2.0	24.1
Norway	70.5	34.4	11.2 (42.4)	4.8 (6.0)	555	480	2.6	21.0
Greece	104.3	22.9	7.3 (33.6)	5.5 (8.3)	277	243	1.8	18.2
UK–England	110.6	18.1	4.9 (23.2)	6.5 (9.7)	227	156	1.2	51.9
UK–Wales	79.4	17.1	8.9 (16.7)	6.1 (9.1)	227	327	1.2	41.0
Netherlands	48.4	16.1	6.6 (26.2)	7.6 (10.3)	365	335	0.8	27.5
Ireland	26.6	8.4	10.9 (35.5)	4.8 (6.7)	389	273	0.6	29.4

ED: emergency department, LOS: length of stay, SRVFs: selected radiologically verifiable fractures.
[1] All figures are age- and sex-standardized

Limitations

Several criticisms have been raised on the use of ED based surveillance data, that may also compromise our incidence figures. ED based surveillance data are seldom population based (representativeness), may not capture all cases (sensitivity) and systematically miss specific patient groups such as those with very serious injuries (bias), and records may be incomplete [10]. In our study, the low incidence and specific age distribution of the Irish data is due to low coverage (2%), and to participating hospitals not being representative for the whole population [17]. The Austrian data shows a very atypical distribution of SRVFs, but despite the low coverage (7%) the data from participating hospitals have been shown to be representative of all hospitals as for incidence of admissions and distributions by age, sex, and type of injury [15, 17]. The Welsh data shows a high rate of missing data (Table 4.1), that were randomly distributed. We assumed this to be valid, as is suggested by the similar distribution of SRVFs with England (Table 4.2). Any data gaps and possible other biases that have been identified and that hamper data comparability, signal the importance of good quality injury surveillance.

Our analyses were limited to the ED treatment and in-hospital care costs associated with home and leisure injuries. These are known to account for only 55% of total medical costs of injury in the Netherlands [5]. Inclusion of outpatient care, rehabilitation services, primary care and social services (e.g. home care) costs across all countries would probably increase the importance of severe, hospitalized injuries, particularly those affecting older people. The inclusion of these additional data sources might also change the country rankings of costs of home and leisure injuries as some may invest more heavily in rehabilitation and social care to reduce hospital costs.

Discussion

This study demonstrates considerable cross national variation in home and leisure injuries incidence among European countries. This variation can partly be explained by the measure chosen to measure incidence (ED visits) combined with differences in health systems characteristics. When adjustment is made for differences in health systems characteristics, by limiting the perspective to injuries with an inherent need for ED treatment (SRVFs), a high degree of cross national variation in incidence remains, particularly in children and older people.

When countries are ranked by incidence, the UK and Greece top the table with Austria being quite low whereas when countries are ranked by costs the UK is at the bottom of the table with Austria, Denmark, Norway, and Greece showing high costs. Major constituents of high per capita costs in the top four countries are a high incidence of moderate severity injuries such as SRVFs (Austria, Greece), health system and trauma policy characteristics (high admission rates and hospital LOS in Austria and Norway), and high unit costs of health care (Norway, Denmark). In most countries, older people contribute proportionately more to the health care costs of injury due to a combination of high incidence of injuries requiring hospital admission and longer lengths of stay.

The cross national analyses presented here can be viewed as a validation of national ED surveillance activities, demonstrating amongst others the similar age distribution of HLI in all countries. We believe that the robustness of the data, critically assessed under "Limitations", should primarily be assessed in the context of the purpose of the analyses, which was to identify cross national variation in incidence and health care consumption (or costs) and to find explanations for this variation. This could help to identify problems in injury epidemiology and health care policy that need specific attention and may be modified. Our analyses have identified a number of these issues.
Firstly, in all countries the incidence of HLI is high in childhood and older people but there is considerable cross national variation. When the analysis is limited to SRVFs, which should remove some of the differences between health systems this finding remains. This supports the need for additional research in the possible causes of the remaining variation in true incidence, such as differences in environmental hazards, risk behavior, socioeconomic position, or other personal risk factors. For instance, traffic injury mortality is higher among lower educated men [20], and a positive association has been demonstrated between sports injuries and higher socioeconomic position, and between poverty and injuries due to violence [21]. The outcomes of such analyses may provide strong arguments for targeted injury control measures.
Secondly, the cross national data on health care consumption and costs indicate possible inefficiencies of health systems. In particular, the large variations in hospitalization rates between countries and in lengths of stay, even when restricted to SRVFs, point in this

direction. However, we did not collect any data on person-based outcomes and so no definitive conclusions can be drawn.
Thirdly, the present study confirms that the incidence of home and leisure injuries (and likely other causes of injury) is very much dependent on the measure that is used, e.g. the number of ED visits or some indicator of injury severity (i.e. SRVFs), an issue that has been previously raised [18, 22, 23]. Whilst limiting the sample to SRVFs seemed to improve the comparison of incidence across countries, as would be expected, we believe that further validation studies are necessary for this indicator [24]. A major drawback of the SRVFs as an indicator of moderately severe injury incidence is that important severe non-fracture injuries, such as extensive burns, major soft tissue injuries and brain injuries and some important fractures (skull, vertebral column) are not included. However, most hospital databases do not include a measure of severity. Therefore, routinely collected Abbreviated Injury Scores (AIS) could help overcome the limitations of distinguishing between more and less severe conditions on the basis of ICD codes or diagnosis codes used within most emergency departments.

The use of total ED visits as a measure of injury incidence is sensitive to health system characteristics [10]. The SRVF indicator was designed to provide a measure, albeit for a limited category of injuries, which would be less affected by access characteristics. When the analysis was restricted to SRVFs only, countries with a high proportion of SRVFs increased in rank of incidence, and the cross-national variation in injury incidence also increased, particularly in children and older people. This indicates that there are large national variations in the true incidence of injuries between participating countries. The varying proportions of SRVFs among total ED visits in the EU countries furthermore indicates that part of the variation in total ED visits is due to health systems characteristics. This hypothesis can be supported by secondary data on general practitioner (GP) capacity per country [19]. Greece and England have the highest number of ED visits, and the lowest GP capacity (almost zero and 0.5 per 1000 population, respectively). In contrast, Austria has the highest GP capacity (1.3 per 1000 population) and the highest proportion of moderately severe injuries (SRVFs) among ED visits, suggesting that minor injuries are predominantly treated by GPs.

Our cross national analysis of injury incidence data underlines the importance of ED based injury surveillance systems. Data on ED treated injuries provide a more complete picture compared to data restricted to hospitalized or fatal injuries. The distribution of types of injury and socio-demographic variables is quite different between hospitalized and non-hospitalized injuries [25]. Furthermore, non-hospitalized injuries are a major contributor to total injury medical costs in some countries, particularly the UK (Table 4.3).

The present research could benefit from improvements in injury surveillance, particularly the coverage and completeness of registration, and could be extended by including information from additional countries. We have already observed a high variation of injury incidence and medical costs of injury among relatively homogeneous countries in terms of economic development. Inclusion of data from other countries would further help our understanding of these variations. International comparative studies demonstrating variability in incidence, treatment and outcomes are the key to developing testable hypotheses to support injury prevention and improvements in health care efficiency.

References

1. Morrison, A. and D.H. Stone, Injury mortality in the European Union 1984-1993. Eur J Public Health, 2000. 10: p. 201-7.
2. Polinder, S., W.J. Meerding, S. Mulder, E. Petridou, et al., Assessing the burden of injury in six European countries. Bull WHO accepted for publication, 2006.
3. Corso, P., E. Finkelstein, T. Miller, I. Fiebelkorn, et al., Incidence and lifetime costs of injuries in the United States. Inj Prev, 2006. 12(4): p. 212-8.
4. Polinder, S., W.J. Meerding, M.E. van Baar, H. Toet, et al., Cost estimation of injury-related hospital admissions in 10 European countries. J Trauma, 2005. 59(6): p. 1283-90.
5. Meerding, W.J., S. Mulder, and E.F. van Beeck, Incidence and costs of injuries in The Netherlands. Eur J Public Health, 2006. 16(3): p. 272-8.
6. Mulder, S., Recording of home and leisure accidents: differences between population surveys and A&E department surveillance systems. Int J Cons Saf, 1997. 4: p. 165-78.
7. Quinlan, K.P., M.P. Thompson, J.L. Annest, J. Peddicord, et al., Expanding the National Electronic Injury Surveillance System to monitor all nonfatal injuries treated in US hospital emergency departments. Ann Emerg Med, 1999. 34(5): p. 637-45.
8. Lyons, R.A., S. Jones, A. Kemp, J. Sibert, et al., Development and use of a population based injury surveillance system: the all Wales Injury Surveillance System (AWISS). Inj Prev, 2002. 8(1): p. 83-6.
9. Krug, E.G., Injury surveillance is key to preventing injuries. Lancet, 2004. 364(9445): p. 1563-6.
10. Stone, D.H., A. Morrison, and G.S. Smith, Emergency department injury surveillance systems: the best use of limited resources? Inj Prev, 1999. 5(3): p. 166-7.
11. Roberts, I., Research priorities for injury prevention. Inj Prev, 2001. 7(1): p. 2-3.
12. Petridou, E., N. Dessypris, C.E. Frangakis, M. Belechri, et al., Estimating the population burden of injuries: a comparison of household surveys and emergency department surveillance. Epidemiology, 2004. 15(4): p. 428-32.
13. Murray, C.J.M., A.D. Lopez, and eds., The global burden of disease: a comprehensive assessment of mortality and disability from diseases, injuries and risk factors in 1990 and projected to 2020. 1996, Cambridge, MA: Harvard School of Public Health.
14. The World Health Organization MONICA Project (monitoring trends and determinants in cardiovascular disease): a major international collaboration. WHO MONICA Project Principal Investigators. J Clin Epidemiol, 1988. 41(2): p. 105-14.
15. Polinder, S., W.J. Meerding, H. Toet, M.E. van Baar, et al., A surveillance based assessment of medical costs of injury in Europe: Final report. 2004, Erasmus MC, Department of Public Health: Rotterdam.
16. Dessypris, N., E. Petridou, Y. Skalkidis, M. Moustaki, et al., Countrywide estimation of the burden of injuries in Greece: a limited resources approach. J Cancer Epidemiol Prev, 2002. 7(3): p. 123-9.

17. Lyons, R.A., S. Polinder, C.F. Larsen, S. Mulder, et al., Methodological issues in comparing injury incidence across countries. Int J Inj Contr Saf Promot, 2006. 13(2): p. 63-70.
18. Langley, J., S. Stephenson, C. Cryer, and B. Borman, Traps for the unwary in estimating person based injury incidence using hospital discharge data. Inj Prev, 2002. 8(4): p. 332-7.
19. OECD, OECD Health Data 2005. 2006, OECD.
20. Borrell, C., A. Plasencia, M. Huisman, G. Costa, et al., Education level inequalities and transportation injury mortality in the middle aged and elderly in European settings. Inj Prev, 2005. 11(3): p. 138-42.
21. Pickett, W., M. Molcho, K. Simpson, I. Janssen, et al., Cross national study of injury and social determinants in adolescents. Inj Prev, 2005. 11(4): p. 213-8.
22. Cryer, C., J.D. Langley, S.N. Jarvis, S.G. Mackenzie, et al., Injury outcome indicators: the development of a validation tool. Inj Prev, 2005. 11(1): p. 53-7.
23. Langley, J., International comparisons: we need to know a lot more. Inj Prev, 2001. 7(4): p. 267-9.
24. Polinder, S., W.J. Meerding, R.A. Lyons, J.A. Haagsma, et al., International variation in clinical injury incidence: exploring the performance of indicators based on health care, anatomical and outcome criteria. submitted, 2006.
25. Centers for Disease Control and Prevention, Ten Leading Causes of Death, 1995. 1997, CDC: Atlanta.

5

Cost estimation of injury related hospital admissions in 10 European countries

Suzanne Polinder, Willem Jan Meerding, Margriet E. van Baar, Hidde Toet, Saakje Mulder, Ed F. van Beeck, and the EUROCOST reference group.

Journal of Trauma 2005; 59: 1283-1291.

Abstract

Background Injuries are a major cause of total health care costs. Cost estimations may help identifying injuries and high risk-groups to be considered for potential intervention.
Methods Hospital Discharge registers of 10 European countries were used to estimate injury incidence. Consensus was reached between the participating countries about methodology, definition, classification, cost measurements and valuation, to maximize cross-national comparability of outcomes. The data of the countries were also used to give an estimate of the costs per capita by age and sex, type of injury and external cause in Europe.
Results Large international differences were observed in injury incidence and associated costs related to hospital admissions, with relatively high costs per capita for Austria, followed by Denmark and Norway. In Greece, Italy, Ireland and Wales intermediate costs per capita were found and these costs were relatively low for Spain, England and the Netherlands. The patterns of costs by age, sex, injury type, and external cause are quite similar between the countries. For all countries, costs per capita increase exponentially in older age groups (age 65^{+}), due to the combined effect of high incidence and high costs per patient. The elderly females account for almost triple costs compared to same age males. Young children and male adolescents are also high-cost groups. Highest costs were found for hip fractures, fractures knee/lower leg, superficial injuries, skull-brain injuries, and spinal cord injuries. Home and leisure injuries (including sport injuries) and occupational injuries combined make a major contribution (86%) to the hospital costs of injury.
Conclusions Elderly patients aged 65 and older, especially women, consume a disproportionate share of hospital resources for trauma care, mainly caused by hip fractures and fractures knee/lower leg, which indicates the importance of prevention and investing in trauma care for this specific patient group.

Introduction

Injuries are a major cause of total health care costs in the industrialized world. Because injuries represent a wide variety of external causes and health consequences, comprehensive and detailed information on health care costs may help to identify previously unnoticed health problems within this field [1]. Similar to indicators of burden of disease, cost estimates provide a measure that enables rapid comparison among several types of injury that differ with respect to severity and health care need [2-4]. This may help policy makers to set priorities in injury prevention and trauma care. Comprehensive cost estimates subdivided by injury diagnoses, external cause and socio-demographic indicators show at a glance where costs might potentially be saved or where interventions are most needed.

The international application of injury cost models, may enhance its value for policy-making purposes. An international comparison of costs can both show common problems for several countries, as well as specific problems for individual countries. This, however, is only possible when data and methods used are harmonized between countries. So far, within Europe, several cost of injury studies were conducted [5-10]. These studies, however, show large differences with respect to their methodology, including comprehensiveness, matters of definition and classification, and the way they measure and value costs [2]. So far, they are limited to specific countries, injuries, health care sectors, and age groups. Because of incomparable methods, the differences and commonalities of medical costs of injury between European countries are not known. Therefore, within the framework of an international project (EUROCOST), a uniform method with several harmonization procedures was applied in 10 European countries [11].

In this chapter the following question is addressed: what are the costs of injury-related hospital admissions in Europe, subdivided by country, age, sex, injury type and external cause?

Materials and methods

Data sources

In the EUROCOST project the following countries participated: Austria, Denmark, England, Greece, Ireland, Italy, Netherlands, Norway, Spain, and Wales. For the EUROCOST project, two primary data sources were used to estimate the incidence and health care consumption for each country: Hospital Discharge Registers (HDR) with (almost) full national coverage and the Emergency Department (ED), sample based, surveillance systems (both from the year 1999). This chapter focuses only on the admitted injury patients. HDR-data were used as primary data source to estimate injury incidence of admitted patients for all injuries combined (intentional and unintentional). For Greece we used the ED data system to estimate the number of hospitalisations, since for this

Table 5.1 Description of the data system used per country

Country	Name data system	Coverage	Registered cases
Austria	HDR (Hospital Discharge Register)	100%	187 225
Denmark	NDR (National Discharge Register)	100%	99 618
Greece	EDISS (ED injury surveillance system)	100%[a]	144 000
Ireland	HIPE (Hospital Inpatient Enquiry)	95%	58 196
Italy	HDR (Hospital Discharge Register)	90-95%	928 317
Netherlands	LMR (Dutch Information System)	100%	102 768
Norway	NIR (National Injury Register)	100%	66 962
Spain	HDR (Hospital Discharge Register)	90/30%[b]	194 856
England	HDR (Hospital Discharge Register)	100%	632 179
Wales	HDR (Hospital Discharge Register)	100%	48 266

[a] National estimates derived from ED visits
[b] Coverage of Spain: 90% of public and 30% of private hospitals

country no HDR data was made available. The data systems that were used are presented in table 5.1. This shows coverage rates of 90 to 100% of the HDR systems of all countries, except Spain where 90% of the public hospitals, but only 30% of the private hospitals is covered. For Greece the respective figures are based on the number of the ED visits from which the total number of hospital admissions can be approximated [12]. Figure 5.1 gives a description of the age distribution for admitted injury patients per country. In Ireland and Greece the admitted injury population is relatively young. For the other countries the percentage of patients above the age of 65 varies from 65 to 75%.

Injury incidence

All participating countries delivered HDR data using the same inclusion criteria, definitions and classifications. Based upon this international agreement, similar selections of accidents (i.e. external causes), injuries (i.e. medical diagnoses) and cost elements (i.e. health care sectors) were studied in all countries. In our analysis only injury principal diagnosis were included, and cases with an injury diagnosis as a secondary or subsequent diagnosis were not included in the analysis. Selecting an injury on the bases of any diagnostic field is problematic, since some countries had only information available about the principal diagnosis. Furthermore, in many cases where the injury diagnosis appears in the second or subsequent diagnosis fields it would be difficult to determine if the person would have been ‘admitted’ to hospital if they had only the injury [13]. However, only including injury principal diagnosis will result in a slight underestimation of the injury incidence of admitted patients.

We used the international classification of disease codes E800 to E999 (ICD-9) [14] to select and classify injuries, except 'misadventures to patients during surgical and medical

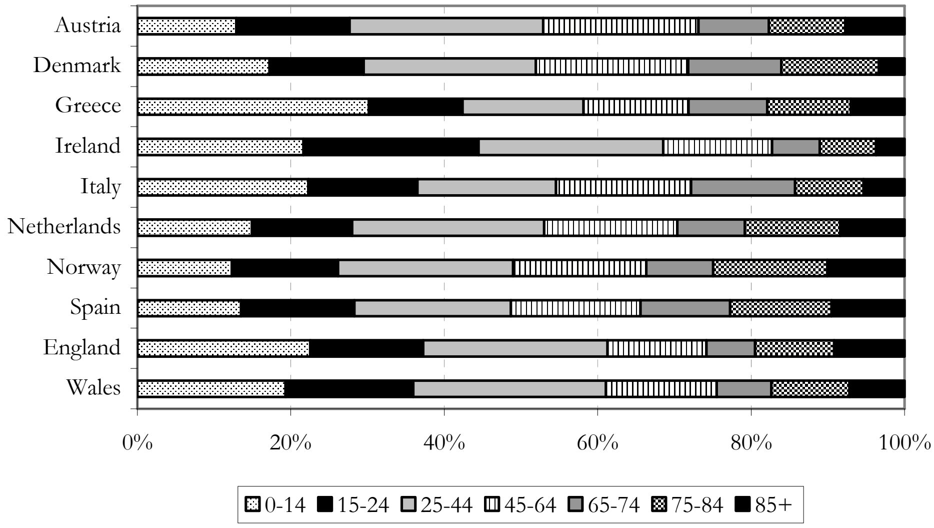


Figure 5.1 Age distribution for admitted injury patients by country

care' (ICD-9 E870-876), 'surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure' (ICD-9 E878-879), 'drugs, medicaments and biological substances causing adverse effects in therapeutic use' (ICD-9 E930-E949), and late effects of injury (ICD-9 E905-E909). Unintentional injuries (E47-E53), including transport injuries (E470-E474, E479), and intentional injuries (E54-E56) were analysed. Furthermore, injuries were classified by location and type into 39 groups (and an aggregation level of 29 groups) [15] after consultations with experts in traumatology, orthopaedics, and rehabilitation, to represent groups of patients that have homogeneous health care consumption.

Day cases and inpatients with length of stay of zero were both classified as a day patient, and were excluded from the analyses presented. Due to the lack of reliable information on re-admissions (they could only be distinguished for three countries), these are included in all analyses as first admissions. To adjust for differences in the demographic composition of the countries, age-standardized (18 groups) and sex-standardized incidence rates (per 1000) and costs per capita (mean costs per inhabitant) were calculated for the year 1999 using the direct method of standardisation. The total population of the participating countries was used as the reference population.

Cost calculations

An incidence-based approach was used, calculating the medical costs of injuries occurring in a specific year (1999). A full description of the cost model can be found in the final

Table 5.2 Calculated comprehensive unit costs (1999) for one inpatient day in hospital and for an Emergency Department visit

Country	Inpatient days in hospital (€)	Emergency Department visit (€)
Austria	461	97
Denmark	465[a]	113
Greece	277	51
Ireland	389[a]	94
Italy	363	81
Netherlands	365	99
Norway	555	122
Spain	298	82
England	227[b]	103
Wales	227[b]	103

[a] No unit costs were available. The comprehensive unit costs were calculated by adjusting the mean costs of an inpatient day in hospital (€381) to national price level.
[b] Econometric estimation of UK hospital costs, from literature [16].

report of EUROCOST [11]. The calculation of the direct medical costs (costs within the healthcare sector) of injury is restricted to hospital costs of inpatients, consisting of costs per inpatient day in hospital and ED costs preceding the hospitalization. The hospital cost of inpatients is the sum of the number of ED visits multiplied by the costs per ED visit and the number of hospital admissions multiplied by length of stay and unit costs per inpatient day.

Information about unit costs was gathered by a questionnaire, filled out by country representatives. The questionnaire was formulated in such a way that for all countries similar cost categories were included. With this information we calculated 'comprehensive unit costs' for each country: unit costs for one inpatient day in hospital and ED visit, on average for all patients (not only injury patients) for general and university hospitals, and public and private hospitals. The comprehensive unit costs include costs for staff, diagnostics, therapy and medication, and overhead costs (e.g. hotel costs and management costs). In case data on specific cost categories were absent for a country, these were estimated based on the mean costs of these categories in other countries, adjusted for differences in price level among countries. For England and Wales, unit cost per inpatient day had to be derived from the literature. An overview of the comprehensive unit costs for each country is given in table 5.2. Costs were calculated in Euros (year 1999).

The data of the 10 participating countries were also pooled to give an estimate of the costs per capita (i.e., absolute costs divided by the number of inhabitants) by injury, external cause, age and sex for the EUROCOST countries in total.

Table 5.3 Costs per capita, incidence and mean costs per patient for admitted injury patients (all causes) per country

Country	Cost per capita (€)	Incidence (per 1,000)	Cost per patient (€)	Mean length of stay (days)
Austria	75	22.9	3,242	6.9
Denmark	51	18.1	2,745	6.1
Greece	30	13.4	2,166	7.6
Ireland	26	15.2	1,690	4.2
Italy	25	16.6	1,506	4.2
Netherlands	19	6.5	2,954	8.4
Norway	42	14.7	2,819	5.0
Spain	14	4.8	2,771	9.3
UK, England	18	11.8	1,418	5.9
UK, Wales	23	15.6	1,399	6.5
EUROCOST	24	12.2	1,965	6.4

Results

Costs by country

Table 5.3 shows the costs of admitted injury patients for each participating EUROCOST country. Large international differences exist in costs per capita of injury related hospital admissions. Compared with the mean costs per capita for the EUROCOST countries in total (€24), Austria generated three times higher costs per capita, followed by Denmark and Norway with (almost) twice as high costs. In Greece, Ireland, Italy and Wales intermediate costs per capita were found and costs per capita were substantial below the mean for Spain, England and the Netherlands. The variation in costs per capita between the countries is mainly caused by the high variation in injury incidence between the countries and is in lesser order due to differences in the mean costs per patient. The mean costs per patient are low in England and Wales and relatively high in Austria, the Netherlands and Norway. Despite different cost levels, age- and sex-patterns between the countries were broadly similar.

Costs by age and sex

Figure 5.2 gives an overview of the costs per capita for all admitted injury patients by age and sex for the EUROCOST countries combined. Peaks in costs per capita are observed among children of 0-4 years old, and among 15 to 24 year old males, due to high incidence rates among these age groups. Costs per capita increase exponentially in older

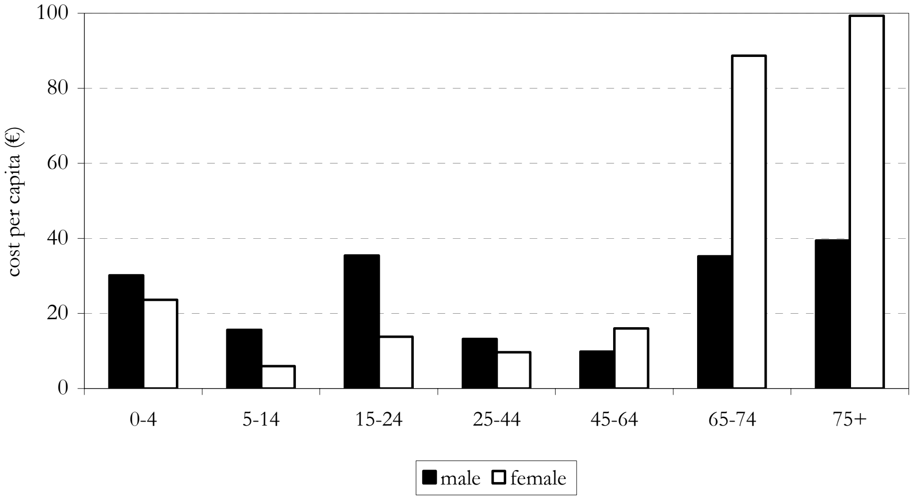


Figure 5.2 Hospital costs per capita (€) for admitted injury patients by age and sex for the EUROCOST countries

age groups (age 65+), and older females in particular, due to the combined effect of high incidence and high costs per patient. In total, 46% of total costs of injury related hospital admissions are due to persons above the age of 65. Though women sustained only 45% of the total number of injuries, they account for 59% of the costs. This is mainly because many of the injuries suffered by older women require a high level of care and females outnumber males at higher ages.

Costs by accident category

Home and leisure, sport, and occupational accidents combined make a major contribution (86%) of the total hospital costs of injury in Europe. The costs of violence and suicide, on the contrary, are both les than 1% of the total medical costs of injury in Europe. Traffic injuries are responsible for the other 12% of hospital costs in Europe. The mean hospital costs per admitted patient are the highest for traffic injuries (€ 2,330), followed by non-traffic injuries (€ 2,140), which are home and leisure, sport, and occupational accidents. They are relatively low for violence (€ 730) and suicide (€ 670). The observed variation is due to large differences in health care use per category.

Costs by injury type

Table 5.4 shows the share of specific injuries in costs per capita, injury incidence and mean costs per patient for admitted patients for the EUROCOST countries. Injury patients admitted with a hip fracture have by far the highest share in total costs, caused by the highest incidence rate and also the highest mean costs per patient. Among the five injuries with highest cost per capita we further observe two injuries with both high

Table 5.4 Injury incidence, costs per capita and mean costs of admitted injury patient by injury group (level 1) ranked by share in costs per capita

Injury group	Cost per capita		Incidence		Mean costs	
	€	Rank	Per 1,000	Rank	€	Rank
Fracture hip / pelvis / femur shaft	10.92	1	2.3	1	5.530	1
Fracture knee/lower leg	2.46	2	0.9	5	3.504	4
Skull-brain injury	1.66	3	1.2	3	2.822	7
Superficial injury	1.16	4	0.9	6	1.312	23
Vertebral column/spinal cord	1.11	5	0.5	13	3.305	5
Fracture ankle	1.03	6	0.5	10	2.636	9
Other and unspecified injury	0.91	7	1.1	4	2.327	11
Fracture upper arm	0.74	8	0.3	17	2.818	8
Open wounds	0.67	9	0.8	7	1.949	14
Poisoning	0.61	10	1.7	2	1.370	22
Fracture wrist	0.59	11	0.8	8	1.374	21
Fracture elbow/forearm	0.59	12	0.6	9	1.726	16
Dislocation/sprain/strain knee	0.56	13	0.4	15	1.727	15
Burns	0.54	14	0.2	18	4.065	2
Internal organ injury	0.39	15	0.2	19	2.865	6
Fracture rib/sternum	0.34	16	0.2	20	2.126	13
Complex soft tissue injury upper extr.	0.30	17	0.4	14	1.440	17
Fracture foot/toes	0.30	18	0.2	24	2.514	10
Open wounds	0.29	19	0.5	12	1.165	25
Complex soft tissue injury lower extr.	0.29	20	0.2	22	3.535	3
Facial fractures	0.27	21	0.5	11	1.379	20
Fracture hand/finger	0.21	22	0.4	16	1.131	26
Sprain/strain ankle/foot	0.20	23	0.1	25	1.430	18
Sprain/strain shoulder/elbow	0.19	24	0.2	23	1.225	24
Fracture clavicle/scapula	0.14	25	0.1	26	2.152	12
Eye injury	0.09	26	0.1	27	1.391	19
Foreign body	0.09	27	0.2	21	1.083	27
Sprain/strain wrist/hand/fingers	0.05	28	0.1	28	775	28

incidence and high costs per patient (fracture knee/lower leg and skull brain injury, including concussion), one injury with high incidence but low costs per patient (superficial injury), and one injury with low incidence and high costs per patient (vertebral column/spinal cord injury). Apart from hip fracture, spinal cord injury, lower extremity injuries (fractures and complex soft tissue injuries), and burns cause high costs per admitted patient. The patterns of the injuries with highest costs per capita per country are quite similar between the countries (Table 5.5).

Table 5.5 Top 5 injuries with highest hospital costs by country

Austria	Denmark	Greece	Ireland	Italy
Hip fracture	Hip fracture	Hip fracture	Hip fracture	Hip fracture
Skull-brain injury	Skull-brain injury	Fracture knee/lower leg	Fracture ankle	Skull-brain injury
Fracture knee/lower leg	Fracture knee/lower leg	Superficial injury	Burns	Vertebral column/spine
Superficial injury	Superficial injury	Fracture ankle	Fracture knee/lower leg	Fracture knee/lower leg
Dislocation/sprain/strain knee	Vertebral column/spine	Skull-brain injury	Open wounds	Superficial injury
Netherlands	**Norway**	**Spain**	**England**	**Wales**
Hip fracture	Hip fracture	Fracture knee/lower leg	Hip fracture	Hip fracture
Skull-brain injury	Skull-brain injury	Hip fracture	Fracture knee/lower leg	Poisoning
Fracture knee/lower leg	Fracture knee/lower leg	Superficial injury	Fracture wrist	Fracture knee/lower leg
Vertebral column/spine	Burns	Vertebral column/spine	Superficial injury	Superficial injury
Poisoning	Poisoning	Skull-brain injury	Fracture upper arm	Open wounds

The costs per capita are for all countries (except Spain) by far the highest for hip fractures (Figure 5.3). Furthermore, fracture knee/lower leg (all countries) and skull-brain injuries and superficial injuries (seven countries) were in the top five of injuries with the highest cost per capita. Skull-brain injuries generate relatively low costs per capita in Ireland, England and Wales, which might be due to traffic safety.
Poisoning (the Netherlands, Norway and Wales) and burns (Norway and Ireland) result in high costs per capita, probably caused by a registration effect. Injury patients with wrist and upper arm fractures generate relatively high costs per capita in England, what might indicate that England has a stringent admission policy for this group of patients.
Austria generates the highest cost per capita for all injury groups shown in figure 5.3. The countries with highest mean cost per capita (Austria, Norway and Denmark) show remarkably higher cost per capita for hip fractures, fracture knee/lower leg, skull brain injury, and spinal cord injury compared to countries with relatively low cost per capita (Netherlands, Spain, Ireland, England and Wales).

In figure 5.4 the costs of the elderly (65^{+}) with a hip fracture are shown as proportion of the total costs. For most countries, 20 to 30% of total costs of admitted injury patients were due to this specific patient group, which accounted for even 40% of total costs in Greece. Only in Spain, the share of this patient group is below 10%. For all countries, females account for 75 to 85% of these costs.

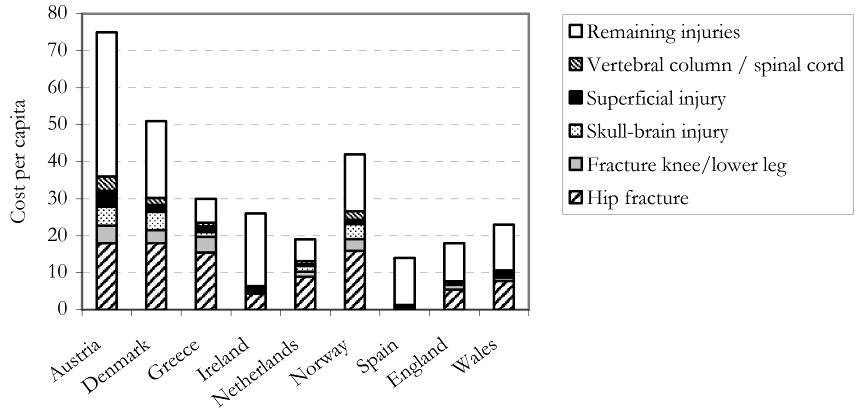


Figure 5.3 Hospital costs by injury type (top 5 highest costs for EUROCOST) by country

Discussion

The cost model provides insight into hospital costs of admitted injury patients in Europe for all external causes, injury types, and age/sex categories. Large international differences in hospital costs are observed, but the pattern of costs per capita by age, sex, injury type and external cause is broadly similar in all countries. Accidents among older people (65^{+}) are a major source of hospital costs in all participating countries. Young children and male adolescents are also high-cost groups. Injuries with the highest hospital costs per capita are hip fractures, fractures of the knee/lower leg, superficial injuries, skull-brain injuries, and vertebral column/spinal cord injuries.

A major strength of our study is that it presents estimates of hospital costs of injuries, based on one uniform method, which makes comparisons between countries and pooling of country specific data possible. Previous cost-of-injury studies were limited to specific injuries, health care sectors, and age groups, which made cross-country comparisons difficult. However, our study also has several limitations, based on using administrative data from different countries.

Application of our cost model has so far been limited to 10 European countries. Countries without nationwide data systems on hospital admissions due to injury (e.g. Germany) did not participate in the EUROCOST project. Expansion of the cost model to other European countries could further enhance its value. Our cost model uses an incidence-based approach. For that reason, the observed incidence rates per country are a primary source of international variation in costs. The incidence of injuries recorded in hospital-based surveillance systems may vary due to real underlying differences in exposure, injury risk, and demographics and/or due to artificial differences in registration and health care practice.

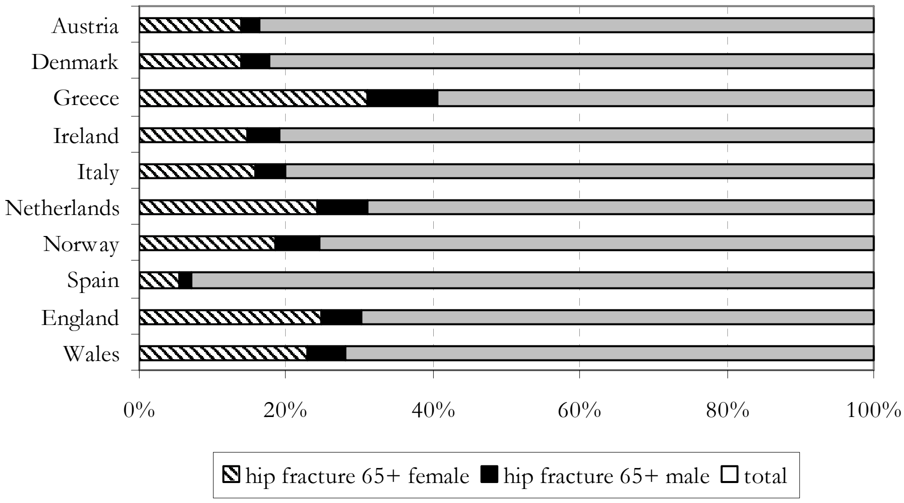


Figure 5.4 Hospital costs of elderly (65+) with a hip fracture as proportion of total costs by country

At the upper end of the spectrum of international differences, Austria has a very high clinical incidence and cost per capita for all injury groups, in particular compared to Spain and the Netherlands at the lower end. Austria has also a relatively high clinical incidence of low severity injuries (superficial and remaining injuries, mainly dislocation/sprain/strain knee, fractures arm/ankle, and open wounds), which indicates a low admission threshold for this country. At the opposite, it seems that Spain and the Netherlands have a high admission threshold, indicated by their high mean length of stay (9.3 and 8.4 days, respectively, compared to a mean of 6.4 days). The low injury incidence in Spain might partly be due to a misclassification of external cause codes in the data system and can partly be explained by an underestimation of admissions of injury patients in private hospitals. In earlier research [10], the incidence for hospitalized traffic patients was double.

It should be considered that registration effects influence the observed patterns by type of injury in our study as well. The high hospital costs for superficial injuries for almost all countries might indicate a conservative coding practice, underestimating other types of injury (such as internal organ injuries) because they are incompletely recognized and recorded. However, earlier research in the United States also found that one half of total hospital costs of acute trauma was caused by minor injuries (ICD/AIS=1, 2) [17]. An important limitation of our data is the unavailability of abbreviated Injury Scale (AIS) scores. Therefore, polytrauma patients (seriously injured patients, usually with multiple injuries) could not be distinguished. The mean costs per polytrauma patient have recently been estimated at €32,166 [18], which far outnumbers the mean costs per patient by injury type found in our study. Other information relating severity of injury was also not available in the data systems. For instance, only one country had information about the proportion of ICU admissions available (Austria 3.4%). Another limitation arises because readmissions could not be distinguished from first admissions in most countries. For the countries with available information (Austria 0.7%; the Netherlands 2.6%; Norway 8.6%) readmissions are mainly caused by hip fractures, skull-brain injuries and poisoning, resulting in an overestimate of injury incidence for these injury types for most countries. Furthermore, day cases were excluded from analyses, since they result in a bias in the estimates of injury incidence, when they are included [13].

In this study we focussed on hospital costs, since no reliable data on health care consumption for other health care sectors was available. Further development of the model should include long term consumption of outpatient care, rehabilitation and/or nursing home treatment. This is particularly relevant for injuries with long-term health care need, such as spinal cord and skull-brain injury [19]. Earlier studies show that hospital care comprises on average 69% of total health care costs in the Netherlands [19], 73% in the United States [20], and 71% in Australia [21].

Our results confirm outcomes of other studies in which hip fractures, mainly due to home and leisure injuries among elderly people, and skull-brain injuries were found as major sources of injury costs [1, 19]. In the United States, it was also found that spinal cord injuries accounted for a large share in total hospital expenditures [17]. The high costs of fractures of the knee and/or lower leg (9%), and of lower extremity injuries in general (54% of total costs) are consistent with findings in Sweden (46% of health care costs of unintentional injuries) [5], and in the United States (45% of hospital costs of injuries) [17]. In a classical study from the United States [22] medical costs for admitted injury patients were estimated at about $8,800 per capita (adjusted for inflation up to 1999), which is more than three times the estimate in our present study ($2,600). This difference can partly be explained by the use of charges in stead of unit costs in the United States cost calculations. However, in another cost study in the United States [17] twofold greater mean costs for admitted injury patients were also found ($5,400). Because many methodological and country-specific issues may cause differences between Europe and the United States, a full comparison will need a specific study, with harmonized methods for the United States and Europe.

The total hospital costs generated by injuries indicate the relative importance of injuries in the healthcare sector as a whole and may be useful in convincing politicians of the importance of preventing injuries and investing in trauma care. Our cost model can be used for policy priority setting by identifying injuries and risk-groups to be considered for potential intervention. The future development of the cost model concerns the inclusion of more cost items (e.g. costs of extramural care, direct non-medical costs) and countries to make prioritising possible based on total expenses. For purposes of setting priorities in injury prevention and trauma care, detailed information about external causes, severity (AIS/ISS), and polytrauma should be available, along with information about economic costs as assessed in this study. Moreover, it would be worthwhile to analyse the differences in costs for specific injury groups (e.g. fractures, brain injury) in more detail and disentangle the effect of differences in treatment and operation strategies and differences in the way trauma care is delivered (including the specialties involved, such as trauma surgeons, orthopedic surgeons and neurosurgeons). Therefore, research in this area should be encouraged, including international studies on costs of polytrauma with the help of trauma center databases.

Based on our current study, we conclude that the elderly beyond age 65 consume a disproportionate share of hospital resources for trauma care, mainly caused by hip fractures and fractures of the knee/lower leg. They constituted only 16% of the European population in 1999, but accounted for 40% of total hospital costs [16], and the proportion of the population that is elderly is growing rapidly. Additional work should focus on societal cost benefit analyses of interventions targeting elderly, quality of life following trauma and the injury prevention needs (e.g. prevention of falls) of the elderly. Other priority areas are skull-brain injuries, spinal cord injuries, burns, and complex soft tissue injuries of the lower extremities, deserving special attention as being the most important 'low frequency, high impact' types of injury. Our cost model can contribute to policy setting by identifying types of injuries and high cost-groups for potential intervention.

References

1. Mulder, S., W.J. Meerding, and E.F. Van Beeck, Setting priorities in injury prevention: the application of an incidence based cost model. Inj Prev, 2002. 8(1): p. 74-8.
2. Meerding, W.J., Describing health and medical costs, and the economic evaluation of health care: applications in injuries and cervical cancer, in Department of Public Health. 2004, ErasmusMC: Rotterdam.
3. MacKenzie, E.J., J.H. Siegel, S. Shapiro, M. Moody, et al., Functional recovery and medical costs of trauma: an analysis by type and severity of injury. Journal of Trauma, 1988. 28: p. 281-97.
4. Segui-Gomez, M. and E.J. Mackenzie, Measuring the Public Health impact of injuries. Epidemiol Rev, 2003. 25: p. 3-19.
5. Lindqvist, K.S. and H. Brodin, One-year economic consequences of accidents in a Swedish minicipality. Accident Analysis and Prevention, 1996. 28: p. 209-219.
6. Kopjar, B., Costs of health care for unintentional injury in Stavanger, Norway. European Journal of Public Health, 1997. 7(3): p. 321-327.
7. Bauer, R., Overall costs to the Austrian national economy from home and leisure accidents. European Journal of Consumer Safety, 1995. 2(7).
8. Beeck van, E., Medical costs and economic production losses due to injuries in the Netherlands. Journal of trauma, 1997. 42: p. 1116-1123.
9. Kidholm, K. and J. Soegaard, A study of the cost of injury in road accidentes (in Norwegian), in CHS working paper, O.U. Press, Editor. 1997.
10. Bastida, J.L., P.S. Aguilar, and B.D. Gonzalez, The economic costs of traffic accidents in Spain. J Trauma, 2004. 56(4): p. 883-8; discussion 888-9.

11. Polinder, S., W.J. Meerding, H. Toet, M.E. Baar, et al., A surveillance bases assessment of medical costs of injury in Europe: phase 2. 2004, Consumer and Safety Institute: Amsterdam.

12. Dessypris, N., E. Petridou, Y. Skalkidis, M. Moustaki, et al., Countrywide estimation of the burden of injuries in Greece: a limited resources approach. J Cancer Epidemiol Prev, 2002. 7(3): p. 123-9.

13. Langley, J., S. Stephenson, C. Cryer, and B. Borman, Traps for the unwary in estimating person based injury incidence using hospital discharge data. Inj Prev, 2002. 8(4): p. 332-7.

14. WHO, International Classification of Diseases; 9th edition. 1997, World Health Organisation: Geneva.

15. Meerding, W.J., H. Toet, S. Mulder, E.F. van Beeck, et al., A surveillance based assessment of medical costs of injury in Europe: phase 1. 2002, Consumer Safety Institute: Amsterdam.

16. http://www.cc.uoa.gr/health/socmed/hygien/eunese/, The right for a better Quality of life, in European Network for safety among elderly, EUNESE, Editor. 2004.

17. Mackenzie, E.J., J.A. Morris, G.S. Smith, and M. Fahey, Acute hospital costs of trauma in the United States: implications for regionalized systems of care. J Trauma, 1990. 30: p. 1096-101.

18. Schwermann, T., M. Grotz, M. Blanke, S. Ruchholtz, et al., [Evaluation of costs incurred for patients with multiple trauma particularly from the perspective of the hospital] Evaluation der Kosten von polytraumatisierten Patienten insbesondere aus der Perspektive des Krankenhauses. Unfallchirurg, 2004. 107(7): p. 563-74.

19. Meerding, W.J., H. Toet, S. Mulder, and E.F. van Beeck, Health care costs of injury in the Netherlands. Submitted, 2004.

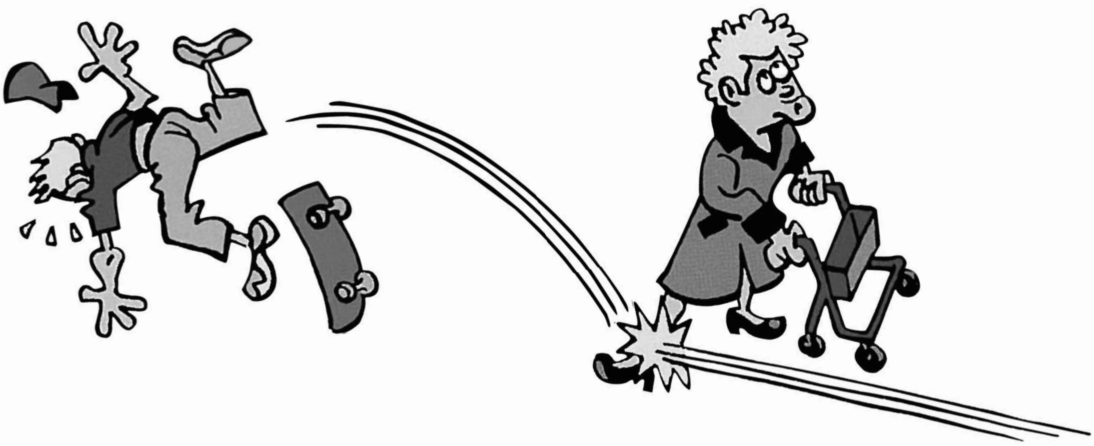
20. Miller, T.R. and D.C. Lestina, Patterns in US medical expenditures and utilization for injury, 1987. Am J Public Health, 1996. 86: p. 89-93.

21. Mathers, C.D., R. Penm, C. Stevenson, and R. Carter, Health system costs of diseases and injury in Australia, 1993-4, in Health and Welfare Expenditure Series No 2, AIHW, Editor. 1998: Canberra.

22. Rice, D.P. and E.J. MacKenzie, Cost of injury in the United States: a report to congress. Institute for Health and Ageing, ed. I.f.H.a. Ageing. 1989, San Francisco: University of California.

Part III

Health impact of injury



6

Functional outcome at 2½, 5, 9 and 24 months after injury in the Netherlands

Suzanne Polinder, Ed F. van Beeck, Marie Louise Essink-Bot, Hidde Toet, Caspar W.N. Looman, Saakje Mulder, Willem Jan Meerding
Accepted for publication in the Journal of Trauma

Abstract

Background The collection of empirical data on the frequency, severity and duration of functioning is a prerequisite to identify patient groups with long-term or permanent disability.

Methods We fielded postal questionnaires in a stratified sample of 8,564 injury patients aged 15 years and older, who had visited an emergency department in the Netherlands. Measurements were at 2½, 5, 9, and 24 months after the injury and included a generic health status classification (EQ-5D), socio-demographic and medical information. We analyzed determinants of long-term functional outcome by multivariate regression analysis.

Results Five months after the injury health status of non-hospitalized injury patients was comparable to the general population's health (EQ-5D summary measure 0.87). Health status of patients admitted for 3 days or less improved until 9 months (0.82). For those admitted more than 3 days health status improved until 24 months (0.48 toward 0.67), but remained below population norms. Hospitalization, age and sex (females), type of injury (spinal cord injury, hip fracture, and lower extremity injury), and comorbidity were significant predictors of poor functioning in the long-term.

Conclusions Recovery patterns vary widely between non-hospitalized, shortly and long hospitalized injury patients. Non-hospitalized injury patients recover within 5 months from an injury while a considerable group of hospitalized injury patients suffer from persistent health problems. Our study indicates the importance of health monitoring with an adapted longitudinal design for injury patients. The time intervals used should match the various stages of the recovery process, which depends on the severity of the injury studied.

Introduction

Disability (i.e. reduced levels of functioning resulting from diseases or injuries) is increasingly seen as an important component of a population's health [1]. This has been recognized in the field of injury prevention and trauma care [2], where the number of survivors of severe injury has rapidly risen [3]. The collection of empirical and epidemiological data on the frequency, severity and duration of functioning is a prerequisite to make 'burden of injury' calculations, and to identify patient groups with long-term or permanent disability who may need specific treatment. However, comparable and representative epidemiological data on functioning are still scarce and incomplete. Most functional outcome studies in this area have so far focused on hospitalized adult patients (mostly within the age range of 15-64 years) with major trauma [4-6], such as poly-trauma [7, 8] and traumatic brain injury [9, 10]. Studies in comprehensive injury populations are scarce [1]. Studies that could be identified used different inclusion criteria for their study population, different generic measures for health status measurement, and different timings of assessment, which makes the available knowledge difficult to compare [11-15]. A considerable share of total disability may be attributable to patients that have never been hospitalized [16-18]. Nevertheless, little is known about non-hospitalized patients A previous study conducted in the Netherlands showed that particularly non-hospitalized patients with vertebral column injury and extremity injury did not fully recover within 2.5 months [15]. Moreover, in children (< 15 years) 75% of all patients with residual disability after injury were non-hospitalized [18]. Moreover, few data are available on the recovery patterns of injury patients from longitudinal studies [6, 13, 15].

The heterogeneity of research conducted so far on functioning and disability in injury patients is likely related to the heterogeneity of injuries itself. Since injuries differ widely with respect to acute functional consequences, speed of recovery, and long-term outcome, insight into the distribution and predictors of short- and long-term functional outcome of both hospitalized and non-hospitalized injury patients should be used to evaluate trauma care and to identify areas for further improvement.

This chapter describes a large follow-up study with four assessments over time (2½, 5, 9 and 24 months after injury) to assess functional outcome and recovery patterns in a comprehensive population of hospitalized and non-hospitalized injury patients, aged 15 years and older. Functional outcome after childhood injury has been presented in chapter 7, since this is a distinct injury population. This study is comparable to an earlier follow-up study on functional outcome in a similar population [15]. Compared to the previous study, we extended the follow-up period (24 in stead of 2.5 and 9 months in non-hospitalized and hospitalized patients, respectively), took a larger sample, included additional items, and made extra efforts to increase the response rates. We address the following questions: a) what is the functional outcome of non-hospitalized and hospitalized injury patients 2½, 5, 9 and 24 months after injury? b) what socio-demographic, injury, and health care related factors are predictive for poor functioning in the long term?

Materials and methods

Study population and follow-up

We conducted a patient follow-up study among 8,564 injury patients aged 15 years and older, who had visited one of the emergency departments (EDs) of the Dutch Injury Surveillance System (LIS) between 8 October 2001 and 31 December 2002. All unintentional and intentional injuries are recorded. LIS has been implemented in 17 hospitals in the Netherlands (15% coverage). These hospitals are geographically spread across the country, and are regarded to be representative for the total population. The study sample was stratified so that severe, less common injuries were overrepresented. Data were collected by postal questionnaires 2½, 5, 9, and 24 months after the injury. All hospitals gave permission for the study before the questionnaires were fielded. For privacy reasons, the first questionnaire was made anonymous. For the second, third, and fourth questionnaire, the patients needed to give permissions by an informed consent form. Non-responders on these questionnaires received a reminder in order to increase response rates. The questionnaire was designed to collect information on functional outcome, socio-demographic and injury related characteristics, and health care use.

Functional outcome

In this study the generic EQ-5D classification of health [19] was used to measure health status because it is simple and takes only 2 minutes to complete; this could allow routine collection of these data in the future [4]. The EQ-5D covers the main health domains that are affected by injury. It is well able to describe a heterogeneous injury population and to discriminate among specific injuries [15]. Moreover, the EQ-5D has been recommended for (economic) evaluation of trauma care at a consensus conference [20]. In this classification, health is defined along five dimensions: mobility, self-care, usual activities, pain/discomfort, and anxiety/depression. Each dimension has three levels: no problem, moderate problem, or severe problem. In addition, a scoring algorithm based on empiric valuations from the U.K. general population and subsequent statistical modeling is available by which each health status description can be expressed into a summary score [21]. This summary score ranges from 1 for full health to 0 for death, and can be interpreted as a judgment on the relative desirability of a health status compared with perfect health. The standard EQ-5D classification does not include cognitive disability. An item was therefore added on cognition ("I have no / some / extreme problems with cognitive function, e.g. memory, concentration, coherence, IQ") [22]. We compared our estimates with descriptive EQ-5D data from the Dutch general population [23].

Socio-demographic, injury, and health care related characteristics

From the literature, potential determinants of functional outcome were identified [5, 6, 24]. These determinants of functional outcome were grouped into socio-demographic (age

Table 6.1 Study population by sex, age, hospitalization, accident category, and type of injury

	Dutch Injury Surveillance System 2000 (n=105947) (%)	Study sample (n=8564) (%)	Response [1] (n=3231) (%)
Sex			
Male	59.0	55.1	48.7
Female	41.0	44.9	51.3
Age			
15-24	25.9	19.3	16.9
25-44	41.6	32.1	28.7
45-64	19.8	22.3	27.7
65-74	5.4	9.1	11.5
75-84	4.9	10.6	10.8
85+	2.3	6.5	4.4
Hospitalization			
Not admitted	91.8	52.2	43.6
1-3 days	4.4	26.8	26.8
>= 4 days	3.8	21.0	29.6
Accident category			
Home and leisure	53.0	53.0	48.6
Traffic	13.6	23.1	28.0
Sport	16.0	14.0	15.0
Occupational	9.8	5.7	5.7
Intentional	4.8	1.8	1.0
Unknown	2.8	2.0	1.6
Type of injury			
Skull-brain injury	2.4	15.9	13.7
Facial fracture, eye injury	3.9	4.1	4.3
Spine, vertebrae	0.5	3.6	4.9
Internal organ injury	0.8	5.2	6.0
Upper extremity fracture	12.9	12.8	13.6
Upper extremity, other	3.9	6.3	6.8
Hip fracture	1.3	5.8	6.3
Lower extremity fracture	6.2	14.2	17.6
Lower extremity, other	8.6	6.0	8.1
Superficial injury, open wounds	51.9	15.8	13.1
Burns	1.4	1.6	0.8
Poisonings	1.5	2.7	1.1
Other injury	4.6	5.9	3.7

[1] Response to the 2½-month questionnaire.

and sex), injury (type of injury, external cause, multiple injury), health care related characteristics (hospitalization and length of stay), and comorbidity. A comorbid condition was defined as a previous disease at the time of trauma according to the patient or the family. Injury and health care related factors could be regarded as proxy indicators of injury severity. The type of injury was picked from the LIS in which up to three injuries can be recorded by type and body region. In case of multiple injuries, we used an algorithm derived from the literature to determine the most severe injury [24]. This algorithm gives priority to spinal cord injury over skull/brain injury (except concussions), hip fracture, and other lower extremity fractures, respectively. Injuries were classified by location and type into 13 groups, which represent the main injury groups. For admitted patients the diagnosis was verified at the individual level with information from the hospital discharge register according to the International Classification of Diseases (9th revision).

Statistical analysis

A non-response analysis was performed by multivariate logistic regression. We tested age, sex, type of injury, external cause, hospitalization and length of stay, health status (EQ-5D summary score), and ambulance transport as possible determinants of non-response. Since response differed between the four questionnaires, separate non-response analyses were conducted for each measurement. All significant variables ($p < 0.05$) were used to adjust for response bias. Subsequently, the respondents were weighted with the inverse probability of response resulting from the final model. In addition to the non-response correction, the data were adjusted for the sample stratification. The resulting weighted data can be considered representative for an ED population of injury patients in the Netherlands. Further statistical analyses were performed on the weighted data.
About 10% of respondents did not report on one or more health domains of the EQ-5D. Because the summary score can only be computed in case of complete information on all health domains, the missing values were estimated by hot-deck imputation, using the reported values of persons with similar scores in the health domains that were reported [25]. Socio-demographic and injury related characteristics were tested as predictors of functional outcome in univariate and step-forward multivariate regression analyses. They were all entered as categorical variables. The extreme unequal weighting of the data due to adjustment for selective non-response and stratification of the sample could influence the confidence intervals of the estimates [26]. In order to take this problem into consideration we used bootstrap analysis. This is a re-sampling technique by which a specified number of population samples are drawn from the data, given the distribution of the population across the variables that are tested. The distribution of the parameters of the bootstrap replica's gives information about the significance of each variable. We performed 500 iterations to test the significance levels of the independent variables. The 95% confidence intervals were determined by using the 2.5% lowest and highest percentiles of 500 replicas. We calculated overall p-values using the regression coefficients and covariance matrix resulting form the bootstrap replicas. Results were regarded significant for $p < 0.05$.

Table 6.2 Mean EQ-5D summary score (95% CI) of hospitalized injury patients by key indicators and time interval (aged 15 years and older)

	2½ months		5 months		9 months		24 months	
	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Total	**0.60**	[0.58 0.63]	**0.70**	[0.68 0.72]	**0.76**	[0.73 0.80]	**0.73**	[0.69 0.75]
Sex	**		**		**		**	
Male	0.65	[0.63 0.68]	0.74	[0.72 0.77]	0.80	[0.77 0.83]	0.77	[0.75 0.79]
Female	0.52	[0.49 0.55]	0.61	[0.58 0.64]	0.64	[0.60 0.68]	0.70	[0.68 0.72]
Age	**		**		**		**	
15-24	0.72	[0.68 0.75]	0.78	[0.72 0.83]	0.84	[0.79 0.89]	0.79	[0.75 0.82]
25-44	0.67	[0.64 0.70]	0.77	[0.74 0.79]	0.83	[0.80 0.85]	0.77	[0.74 0.80]
45-64	0.58	[0.55 0.61]	0.70	[0.66 0.72]	0.76	[0.73 0.79]	0.70	[0.67 0.73]
65-74	0.57	[0.52 0.62]	0.66	[0.61 0.70]	0.69	[0.62 0.74]	0.73	[0.69 0.77]
75-84	0.47	[0.42 0.52]	0.56	[0.51 0.62]	0.58	[0.50 0.65]	0.72	[0.68 0.77]
85+	0.43	[0.35 0.51]	0.47	[0.34 0.58]	0.47	[0.32 0.60]	0.65	[0.59 0.71]
Accident category	**		**		**		**	
Home and leisure	0.54	[0.51 0.57]	0.62	[0.58 0.66]	0.66	[0.61 0.70]	0.74	[0.72 0.76]
Traffic	0.64	[0.61 0.67]	0.73	[0.70 0.75]	0.79	[0.76 0.81]	0.73	[0.71 0.76]
Sport	0.72	[0.69 0.76]	0.84	[0.81 0.87]	0.89	[0.86 0.92]	0.81	[0.79 0.84]
Occupational	0.60	[0.51 0.67]	0.73	[0.63 0.81]	0.77	[0.65 0.86]	0.71	[0.64 0.77]
Intentional	0.74	[0.60 0.85]	0.67	[0.44 0.83]	0.91	[0.72 1.00]	0.84	[0.66 0.94]
Unknown	0.50	[0.40 0.61]	0.61	[0.49 0.72]	0.65	[0.55 0.74]	0.63	[0.52 0.74]
Type of injury	**		**		**			
Skull-brain injury	0.72	[0.68 0.76]	0.78	[0.72 0.82]	0.83	[0.79 0.86]	0.80	[0.77 0.84]
Facial fracture, eye injury	0.72	[0.62 0.81]	0.83	[0.75 0.90]	0.91	[0.82 0.96]	0.80	[0.70 0.89]
Spine, vertebrae	0.46	[0.38 0.52]	0.57	[0.48 0.66]	0.63	[0.50 0.73]	0.64	[0.57 0.70]
Internal organ injury	0.72	[0.67 0.76]	0.78	[0.73 0.83]	0.81	[0.76 0.87]	0.81	[0.76 0.85]
Upper extremity fracture	0.62	[0.58 0.66]	0.72	[0.67 0.77]	0.77	[0.72 0.82]	0.77	[0.73 0.80]
Upper extremity, other	0.68	[0.60 0.77]	0.79	[0.74 0.84]	0.83	[0.76 0.89]	0.81	[0.71 0.90]
Hip fracture	0.43	[0.38 0.48]	0.49	[0.42 0.55]	0.52	[0.45 0.60]	0.67	[0.64 0.71]
Lower extremity fracture	0.51	[0.48 0.55]	0.64	[0.59 0.68]	0.68	[0.63 0.74]	0.67	[0.64 0.70]
Lower extremity, other	0.55	[0.50 0.61]	0.72	[0.66 0.77]	0.79	[0.72 0.85]	0.70	[0.65 0.75]
Superficial injury, open wounds	0.69	[0.64 0.74]	0.74	[0.68 0.79]	0.80	[0.73 0.87]	0.78	[0.74 0.82]
Burns	0.83	[0.54 1.00]	0.92	[0.80 1.00]	0.86	[0.80 0.98]	0.85	[0.19 1.00]
Poisonings	0.84	[0.73 0.94]	0.92	[0.78 1.00]	0.96	[0.85 1.00]	0.91	[0.84 0.98]
Other injury	0.72	[0.64 0.80]	0.78	[0.68 0.86]	0.83	[0.75 0.91]	0.83	[0.74 0.91]
Multiple injury	n.s.		n.s.		n.s.		n.s.	
1	0.59	[0.57 0.61]	0.68	[0.65 0.70]	0.73	[0.69 0.75]	0.75	[0.73 0.76]
2	0.60	[0.55 0.64]	0.71	[0.66 0.76]	0.75	[0.69 0.80]	0.74	[0.70 0.78]
>=3	0.55	[0.50 0.61]	0.66	[0.59 0.72]	0.72	[0.65 0.77]	0.70	[0.64 0.76]

	2½ months		5 months		9 months		24 months	
	Mean	CI	Mean	CI	Mean	CI	Mean	CI
Comorbidity	**		**		**		**	
No	0.66	[0.64 0.68]	0.75	[0.73 0.77]	0.80	[0.77 0.82]	0.76	[0.75 0.78]
1	0.54	[0.51 0.58]	0.65	[0.61 0.68]	0.70	[0.66 0.74]	0.71	[0.69 0.74]
>=2	0.40	[0.34 0.45]	0.46	[0.39 0.53]	0.46	[0.36 0.57]	0.66	[0.60 0.72]

Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands. Convidence intervals (CI) and significance levels were measured by multivariate regression. ** = p value < 0.05. n.s. indicates not significant (significance level 0.05).

Results

Study population

The questionnaires were sent to 8,564 injured patients. We obtained completed first questionnaires from 3,167 patients (37%), 2,384 (75% of the responders of the first questionnaire) completed the second questionnaire, 2,295 (96% of the responders of the second questionnaires) completed the third questionnaire, and 1,781 (78% of the responders of the third questionnaire) completed the fourth questionnaire. Because of stratification, severe injuries such as hospitalized injuries (47.8%), skull/brain injury (15.9%), lower extremity fractures (14.2%), persons aged 65 years and older (26.7%), and traffic injury (23.1%) were overrepresented in the study sample (Table 6.1). In almost half of the cases (48.6%) the injury was due to home and leisure accidents. There were minor differences between respondents and non-respondents (Table 6.1). Males and non-hospitalized patients had a lower chance to respond.

Functional outcome at 2½, 5, 9 and 24 months after injury

The health status (EQ-5D summary score) of non-hospitalized injury patients improved from 0.83 at 2½ months, to 0.87 at 5 months and 0.90 at 9 months (Figure 6.1), which was on average comparable with the Dutch general population norm score (0.87). Patients hospitalized for less than 4 days had a relatively energetic recovery pattern with a health status improving on average from 0.64 until 0.82 after 9 months, but with a significant decrease of their reported health status for the second year after injury (0.75) (Figure 6.1). Specific subgroups that reported a large reduction in functioning were males, persons 15-64 years old, upper and lower extremity injury and facial fractures (data not shown). Patients hospitalized for more than 3 days had on average a relatively low EQ-5D summary score after 2½ months (0.48), which increased until 24 months after injury (0.67). In total, 16% of these patients reached a health state comparable or better than the Dutch general population after 24 months. In figure 6.2 the prevalence of limitations on each EuroQol health domain after 2½, 5, 9 and 24 months are presented for short and long hospitalized patients.

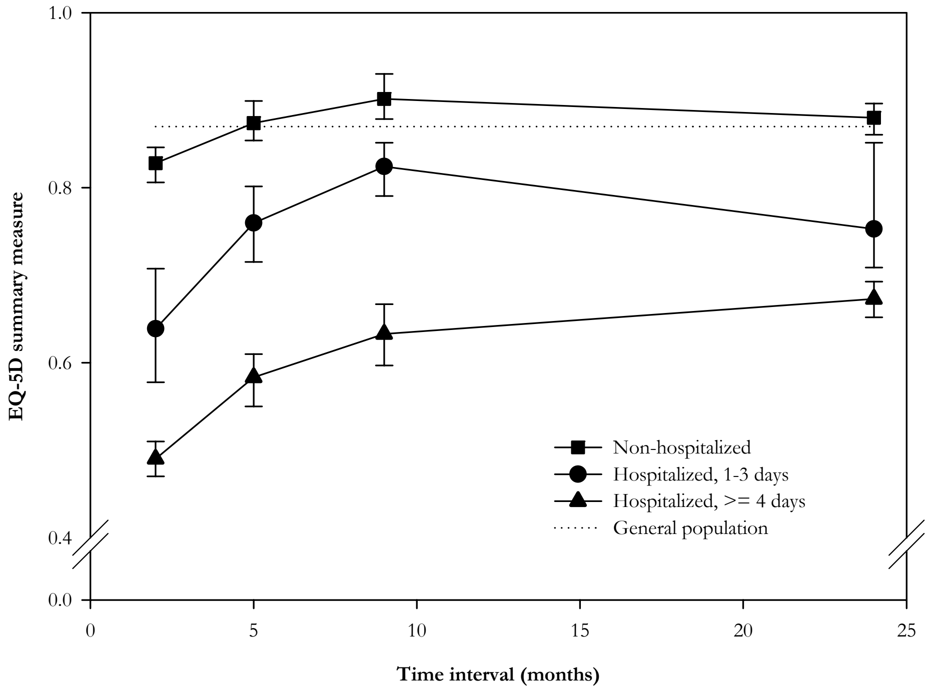


Figure 6.1 EQ-5D summary score by time interval and hospitalization (aged 15 years and older)

Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands. The symbols represent mean values (± standard errors). The mean EQ-5D norm score for the Dutch general population (0.87) is from Hoeymans and colleagues [23].

Most limitations were reported for mobility, performing usual activities and for pain/discomfort for all measurements. For patients with a short hospital stay (1-3 days), limitations on all health dimensions decreased until 24 months after injury except for usual activities and cognition. The prevalence of limitations of longer admitted patients remained above the population norm for all health domains after 24 months: 56% for mobility, 24% for self-care, 54% for usual activities, 60% for pain/ discomfort, 26% for anxiety/depression and 28% for cognition. The prevalence of limitations of non-hospitalized patients remained below the general norm score for all health domains in the long term.

Determinants of long term functional outcome after injury

In table 6.2 data is presented on functional outcome for hospitalized injury patients only, since most non-hospitalized patients fully recovered within 5 months. Males reported a much better health status compared to females at all measurements. The health status improved until 9 months after injury across all age groups.

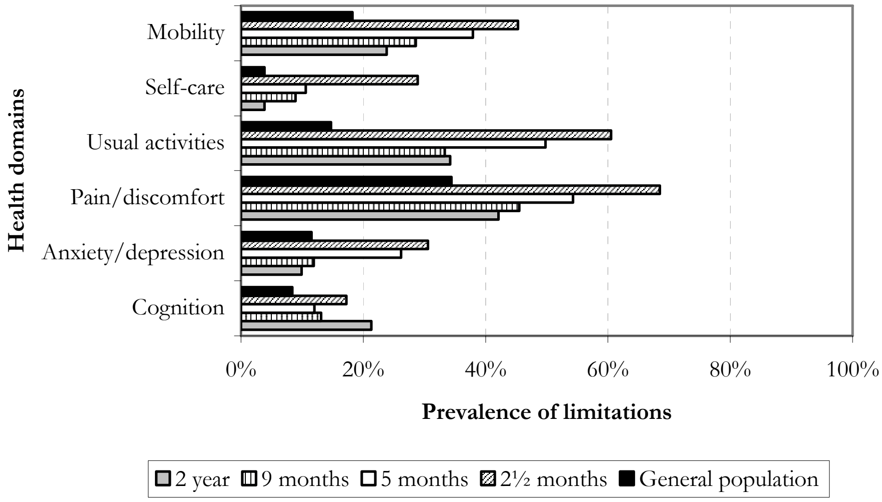


Figure 6.2a Prevalence of limitations (moderate or severe) of the EQ-5D health domains by time interval (%) for 1-3 days hospitalized patients

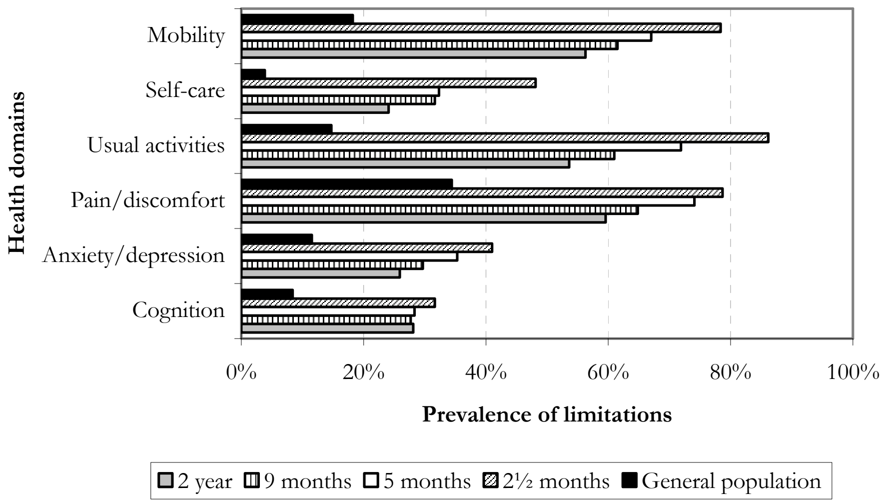


Figure 6.2b Prevalence of limitations (moderate or severe) of the EQ-5D health domains by time interval (%) for 4 or more days hospitalized patients

Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands. The data for the Dutch general population are from Hoeymans and colleagues [23].

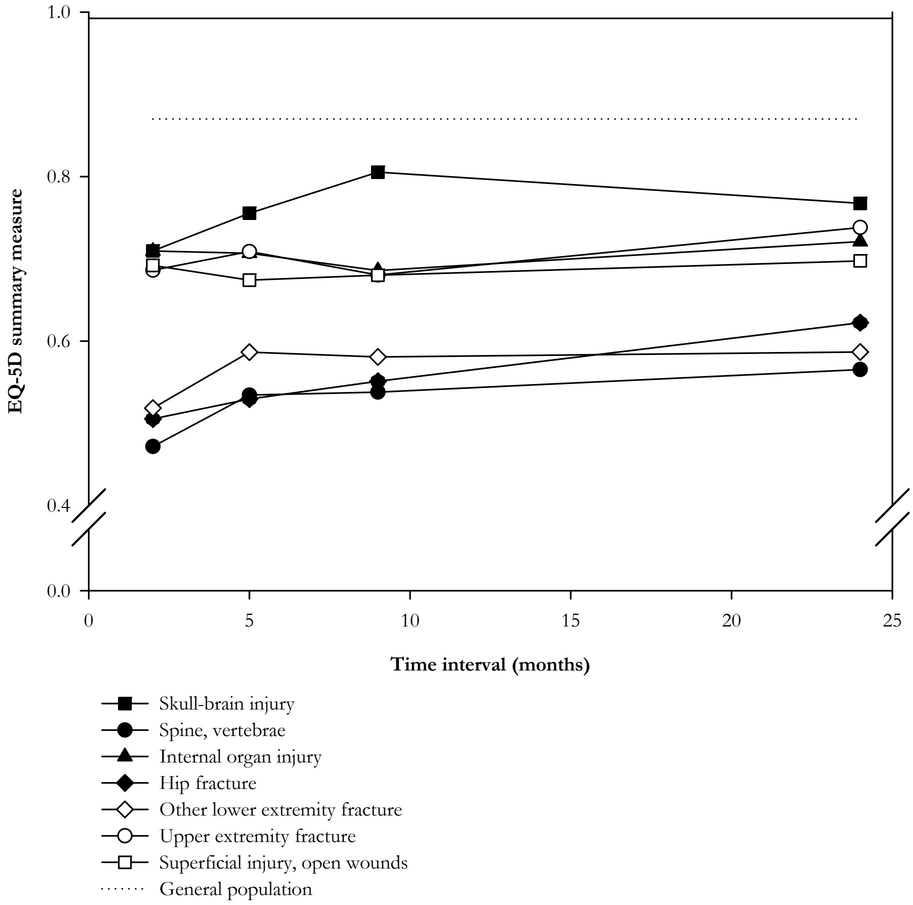


Figure 6.3 EQ-5D summary score by time interval and type of injury (adjusted for age and sex) for hospitalized patients (aged 15 years and older)

Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands.

Thereafter, patients below the age of 65 reported a decreased health status, whereas those older than 65 years reported a notable increase of their health status. At 24 months, patients with injuries of the spinal cord and vertebral column, hip fractures, and lower extremity injuries reported the worst health status as measured by the EQ-5D summary score.

For hospitalized injury patients we specifically analyzed the influence of injury type, comorbidity and multiple injuries on health status, adjusted for age and sex. When adjusted for age and sex the ranking of type of injury of hospitalized patients in terms of quality of life remained almost the same (Figure 6.3), compared to unadjusted outcomes (Table 6.2).

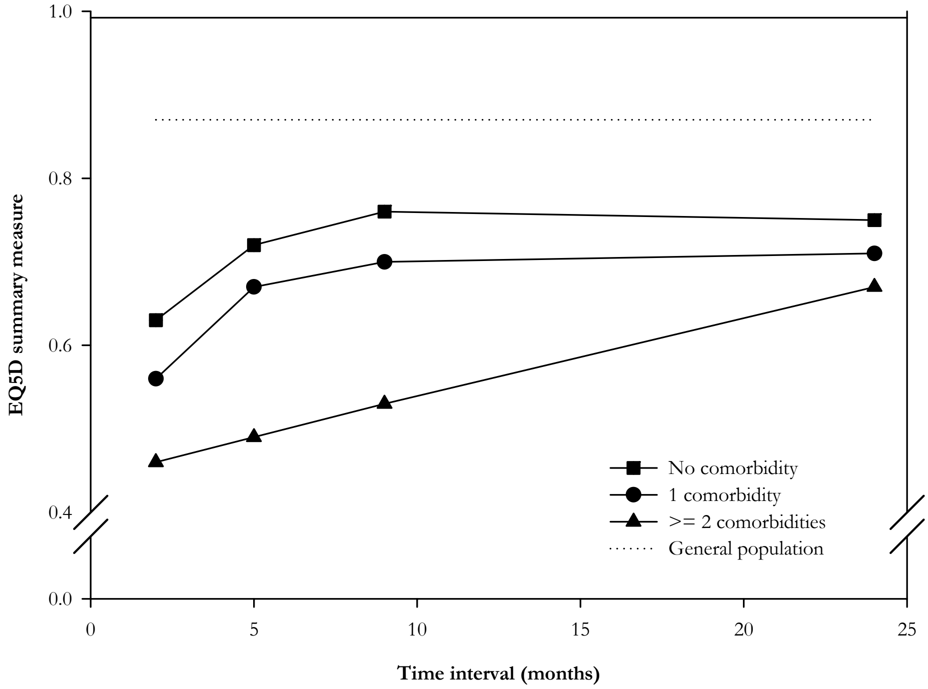


Figure 6.4 EQ-5D summary score by time interval and comorbidity (adjusted for age and sex), for hospitalized patients (aged 15 years and older)

Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands. The data for the Dutch general population (0.87) is from Hoeymans and colleagues [23]. 64.6%, 25.2%, and 10.3% of respondents of the first questionnaire had respectively no comorbidity, 1 comorbidity, or 2 or more comorbidities.

The worst health status was found in patients with spinal cord injury, hip fractures, and other lower extremity fractures, at all measurements. However, the difference between hip fracture and all other injuries became smaller (summary score change from –0.28 to –0.13 compared to superficial injury, 9 month measurement). Patients with a skull brain injury had a considerably higher summary score than patients with vertebral column, spinal cord and lower extremity injuries, also in the multivariate regression analysis differences range from 0.13 to 0.18 at 9 and 24 months, Table 6.3).
The existence of comorbidity significantly influenced the health status after injury in the short and the long term (Figure 6.4). Admitted injury patients with 2 or more comorbidity conditions showed a much slower recovery , while patients with 1 or no comorbidity conditions reached their maximum health status after 9 months. Patients with two or more comorbidities score lower than patients without comorbidities after 9 months (-0.20), but after 24 months this effect almost totally reduced (-0.035) (Table 6.3).

Supplementary multivariate analyses for patients 15-75 years old resulted in a significant influence of comorbidity on functional outcome, while comorbidity had no influence for patients older than 75 (effect size >=2 comorbidities after 24 months: -0.131 and –0.009 respectively; data not shown). Patients with multiple injuries reported a slightly (but not significant) lower EQ-5D summary score in the short and long term (Table 6.3).

Discussion

We conclude that non-hospitalized injury patients reported on average temporary functional limitations, with a health status comparable to the general population's health (0.87) 5 month after injury. Health status of patients admitted for 3 days or less improved until 9 months (0.82), but decreased thereafter (0.75 after 24 months). Injured patients hospitalized for more than 3 days had a relatively low EQ-5D summary score after 2½ months (0.48), and did not reach the health level of the general population after 24 months (0.67 instead of 0.87). For hospitalized patients, age, sex (females), type of injury (spinal cord injury, hip fracture and lower extremity injuries) and comorbidity were significant predictors of functioning 9 and 24 months after injury.
The strength of our study is that it contributes to the empirical knowledge about functioning in a comprehensive group of hospitalized and non-hospitalized injury patients until 24 months after injury. Studies of this type have not yet been reported. We deliberately included minor injuries and non-hospitalized patients in our study. Little is known about the non-hospitalized ED patients. Although the duration and level of disability reported by non-hospitalized injury patients are relatively modest, the total burden of injury may still be high because of the large numbers of patients.

A major limitation was the relatively low response rate for the first questionnaire (37%). This is largely due to the use of postal questionnaires whereas we were limited in the use of response increasing incentives. Due to privacy reasons it was not feasible to use reminders for the first questionnaire, but we did so for the other questionnaires, which resulted in higher response rates than in our previous study (75%, 96% and 78% after 5, 9 and 24 months).
We had much background information about the non-respondents, and adjusted the data for non-response bias after an extensive analysis in which the impact of patient and injury related factors were investigated. An earlier performed follow-up study on functional outcome of hospitalized injury patients with the same study design resulted in comparable outcomes, but the health outcomes at 9 months were probably biased downwards by the low response rate (12%) [15].
Both hospitalized and non-hospitalized patients reported a worse health status after 2½ months compared to the general population. However, for a large group of non-hospitalized patients, this time interval appeared to be too long for measuring the impact of the injury on health status (57% had returned to normal health).

Table 6.3 Effect sizes (and significance) of functional outcome (EQ-5D summary score) of hospitalized patients by Multivariate Regression at 9 and 24 months (aged 15 years and older)

Determinants	9 months	24 months
Baseline^	0.936	0.871
Sex	**	**
Male	0.079	0.073
Female ^	0	0
Age	**	**
15-24 ^	0	0
25-44	-0.051	-0.058
45-64	-0.053	-0.091
65-74	-0.085	-0.061
75-84	-0.076	-0.053
85+	-0.275	-0.137
Type of injury	**	**
Skull-brain injury ^	0	0
Facial fracture, eye injury	0.032	-0.069
Spine, vertebrae	-0.175	-0.178
Internal organ injury	-0.046	-0.059
Upper extremity fracture	-0.132	-0.056
Upper extremity, other	-0.049	-0.040
Hip fracture	-0.174	-0.129
Lower extremity fracture	-0.164	-0.156
Lower extremity, other	-0.150	-0.161
Superficial injury, open wounds	-0.039	-0.106
Burns	0.037	-0.113
Poisonings	0.177	0.105
Other injury	-0.100	-0.028
Multiple injury	n.s.	n.s.
1 ^	0	0
2	-0.058	-0.014
>=3	-0.136	-0.052
Comorbidity	**	n.s.
No ^	0	0
1	-0.052	-0.056
>=2	-0.213	-0.035

^ Baseline = age 15-24, female, skull-brain injury, 1 injury, and no comorbidity. ** Significant ($p<0.05$).
Significance levels are for models including all other significant variables. n.s. = not significant.
Data are corrected for non-response and stratification and are representative for a population of injured patients who visited an ED in the Netherlands.

Because these injuries can be temporarily quite disabling, we recommend to follow non-hospitalized patients until 5 month after injury, but also to collect data within one month after injury, to match the particular speed of recovery. Future research should identify subgroups of minor injury patients with residual disability in the long term that require longer follow-up.

Non-hospitalized injury patients and patients with a short hospital stay reported a decrease in health status after 9 months. Because in the data analysis we eliminated non-response bias as a possible explanation, we hypothesize that these patients might have overestimated their 9 month health status (and possibly also their 5 months health status), since their frame of reference has changed as a result of a temporary decrease in health status after the injury (response shift) [27]. Further research should investigate whether this mechanism applies to injury patients similar as in other patients, and whether response shift is similar in minor and major injuries.

Furthermore, injury patients below the age of 64 reported a decreased health status after 9 months, whereas older patients reported a notable increase of their health state. This might partly be the influence of mortality among the patients with the worst health status and most comorbidities. We conclude that the 9- and 24-month measurements need to be interpreted with caution. Also, the collection of clinical data (e.g. ICU, specific trauma registries) and mortality data parallel to functional outcome during follow-up could help to further interpret the reported patterns of functional outcome.

Hospitalized patients admitted more than 3 days still reported disability after 2-years. Vles and colleagues [4] found that except for the EQ dimension 'self-care', beyond 24 months, longer periods between trauma and moment of follow-up than 2 years did not result in a lower prevalence of disabilities after major trauma. This indicates that the 2-year measurement can be used as stable end situation and that severe injury patients should be followed until 2 years after injury.

The generic EQ-5D instrument appeared to be a feasible and valid instrument for the measurement of functioning and disability in injury patients. The instrument discriminated well among our heterogeneous injury population. However, for specific injuries the EQ-5D does not measure all important health domains. The EQ-5D summary measure does not include memory patterns and/or ability to concentrate, which partly explain the high functional outcome of skull-brain injury patients. A separate item on cognitive ability compensates this gap. Furthermore, information on specific health domains (e.g. hand-arm movement) can be collected with other instruments like the Functional Capacity Index (FCI) [28] or the Health Utility Index (HUI) [29].

Previous studies support our findings that particularly lower extremity fractures, injuries to the vertebral column and spinal cord, and hip fractures impact most on levels of functioning, also when adjusted for socio-demographic variables [4, 24, 30-32]. Other studies confirm that female gender is independently associated with worse functional outcome [5] [4, 15, 18].

Pre-existing comorbidity was reported by 36% of the patients, which is similar to data from the UK [33]. These conditions appeared to have a negative impact on health outcomes, particularly in patients below age 75, as also found in the literature [34-36]. The impact of comorbidities in injury patients should be further examined, particularly the impact of specific comorbidities and in distinct types of injury [37].
In addition to the determinants examined in this chapter, it has become increasingly apparent that also post-traumatic stress disorder (PTSD) and depression are associated with a worse quality of life [6, 38-40]. We measured PTSD after 24 months. The prevalence of cognitive disability appeared to be strongly associated with PTSD (12% and 40% in those without and with PTSD, respectively), but the prevalence of limitations in other health domains was also higher in those with PTSD. These findings will be further examined separately.

We conclude that hospitalized injury patients, particularly females, elderly, patients with multiple co-morbidities, and patients with hip fractures, vertebral column and spinal cord injury, or fractures of the knee/lower leg are at higher risk of poor functioning in the long-term. Trauma care should be targeted at early identification and management of the particular needs of these patients.
Furthermore, our study indicates the importance of longitudinal health surveillance, with adapted measurement intervals and health items for specific injury groups in order to improve the discriminative power between subgroups and to pick up changes over time.

References

1. Van Beeck, E.F., C.F. Larsen, R.A. Lyons, W.J. Meerding, et al., Draft guidelines for the conduction of empirical studies into injury-related disability, European Association for Injury Prevention and Safety Promotion, Editor. 2005, consumer Safety Institute: Amsterdam.
2. Segui-Gomez, M. and E.J. Mackenzie, Measuring the Public Health impact of injuries. Epidemiol Rev, 2003. 25: p. 3-19.
3. Van Beeck, E.F., C.W.N. Looman, and J.P. Mackenbach, Mortality due to unintentional injuries in the Netherlands, 1950-1995. Public Health Rep, 1998.
4. Vles, W.J., E.W. Steyerberg, M.L. Essink-Bot, E.F.v. Beeck, et al., Prevalence and determinants of disabilities and return to work after major trauma. J Trauma, 2005. 58: p. 126-135.
5. Holbrook, T.L. and D.B. Hoyt, The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. J Trauma, 2004. 56(2): p. 284-90.
6. Holbrook, T.L., J.P. Anderson, W.J. Sieber, D. Browner, et al., Outcome after major trauma: 12-month and 18-month follow-up results from the Trauma Recovery Project. J Trauma, 1999. 46(5): p. 765-71.
7. Bouillon, B. and E. Neugebauer, Outcome after polytrauma. Langenbeck's Arch Surg, 1998. 383: p. 228-234.
8. Anke, A.G., J.K. Stanghelle, A. Finset, K.S. Roaldsen, et al., Long-term prevalence of impairments and disabilities after multiple trauma. J Trauma, 1997. 42: p. 54-61.
9. Goldstein, F.C. and H.S. Levin, Cognitive outcome after mild and moderate traumatic brain injury in older adults. J Clin Exp Neuropsychol, 2001. 23(6): p. 739-753.

10. Hellawell, D.W., R.T. Taylor, and B. Pentland, Cognitive and psychosocial outcome following moderate or severe traumatic brain injury. Brain Inj, 1999. 13(7): p. 489-504.
11. Kopjar, B., The SF-36 health survey: a valid measure of changes in health status after injury. Inj Prev, 1996. 2(2): p. 135-9.
12. Baldry Currens, J.A., Evaluation of disability and handicap following injury. Injury, 2000. 31: p. 99-106.
13. Baldry Currens, J.A. and T.J. Coats, The timing of disability measurements following injury. Injury, 2000. 31: p. 93-98.
14. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. J Trauma, 2000. 48(5): p. 841-850.
15. Meerding, W.J., C.W. Looman, M.L. Essink-Bot, H. Toet, et al., Distribution and determinants of health and work status in a comprehensive population of injury patients. J Trauma, 2004. 56(1): p. 150-61.
16. Waller, J.A., J.M. Skelly, and J.H. Davis, Emergency department care and hospitalization as predictors of disability. J Trauma, 1995. 39: p. 632-4.
17. McClure, R.J. and R.M. Douglas, The public health impact of minor injury. Accid Anal Prev, 1996. 28(4): p. 443-51.
18. Polinder, S., W.J. Meerding, H. Toet, S. Mulder, et al., Prevalence and prognostic factors of disability after childhood injury. Pediatrics, 2005. 116: p. 810-817.
19. EuroQol--a new facility for the measurement of health-related quality of life. The EuroQol Group. Health Policy, 1990. 16: p. 199-208.
20. Bouillon, B., H.J. Kreder, E. Eypasch, T.L. Holbrook, et al., Quality of life in patients with multiple injuries--basic issues, assessment, and recommendations. Restor Neurol Neurosci, 2002. 20(3-4): p. 125-34.
21. Dolan, P., Modeling valuations for EuroQol health status. Med Care, 1997. 35: p. 1095-1108.
22. Krabbe, P.F.M., M.E.A. Stouthard, M.L. Essink-Bot, and G.J. Bonsel, The effect of adding a cognitive dimension to the EuroQol multiattribute health-status classification system. J Clin Epidemiol, 1999. 52: p. 293-301.
23. Hoeymans, N., H. LIndert van, and G.P. Westert, The health status of the Dutch population as assessed by the EQ-6D. Quality of Life Research, 2004. in press.
24. Mackenzie, E.J., J.H. Siegel, S. Shapiro, M. Moody, et al., Functional recovery and medical costs of trauma: an analysis by type and severity of injury. J Trauma, 1988. 28: p. 281-297.
25. Rubin, D.B. and N. Schenker, Multiple imputation in health-care databases: an overview and some applications. Stat Med, 1991. 10: p. 585-598.
26. Research Triangle Park, SUDAAN Survey Data Analysis Software, S. BV, Editor. 1993, NC: Research Triangle Institute.
27. Jansen S.J., Stiggelbout A.M., Nooij M.A., Noordijk E.M., et al., Response shift in quality of life measurement in early-stage breast cancer patients undergoing radiotherapy. Qual Life Res, 2000. 9: p. 603-615.
28. Mackenzie, E.J., W.J. Sacco, S. Luchter, J.F. Dittuno, et al., Validating the Functional Capacity Index as a measure of outcome following blunt multiple trauma. Qual Life Res, 2002. 11: p. 797-808.
29. Raat, H., G.J. Bonsel, W.C. Hoogeveen, M.L. Essink-Bot, et al., Feasibility and reliability of a mailed questionnaire to obtain visual analogue scale valuations for health status defined by the health Utilities Index Mark 3. Medical Care, 2004. 42(1): p. 13-18.
30. Holbrook, T.L., J.P. Anderson, W.J. Sieber, D. Browner, et al., Outcome after major trauma: discharge and 6-month follow-up results form the Trauma Recovery Project. J Trauma, 1998. 45: p. 415-323.
31. Jurkovich, G.J., C. Mock, E.J. Mackenzie, and et al., The Sickness Impact Profile as a tool to evaluate functional outcome in trauma patients. J Trauma, 1995. 39: p. 625-631.
32. Butcher, J.L., E.J. MacKenzie, and B.M. Cushing, Long-term outcomes after lower extremity trauma. J Trauma, 1996. 41: p. 4-9.
33. Wardle, T.D., P. Driscoll, and M. Woodford, Medical problems in major trauma. Injury, 1995. 26: p. 137.
34. Wardle, T.D., Co-morbid factors in trauma patients. Br Med Bull, 1999. 55(4): p. 744-56.

35. Sacco, W.J., W.S. Copes, L.W.J. Bain, E.J. MacKenzie, et al., Effect of preinjury illness on trauma patient survival outcome. J Trauma, 1993. 35(4): p. 538-42.

36. Bergeron, E., A. Lavoie, L. Moore, D. Clas, et al., Comorbidity and age are both independent predictors of length of hospitalization in trauma patients. Can J Surg, 2005. 48(5): p. 361-6.

37. Elixhauser, A., C. Steiner, D.R. Harris, and R.M. Coffey, Comorbidity measures for use with administrative data. Medical care, 1998. 36: p. 3-5.

38. Michaels, A.J., C.E. Michaels, C.H. Moon, J.S. Smith, et al., Posttraumatic stress disoreder after injury: impact on general health outcome and early risk assessment. J Trauma, 1999. 47: p. 460-6.

39. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. J Trauma, 2000. 48(5): p. 851-850.

40. Holbrook, T.L., D.B. Hoyt, M.B. Stein, and W.J. Sieber, Gender differences in long-term posttraumatic stress disorder outcomes after major trauma: women are at higer risk of adverse outcomes than men. J Trauma, 2002. 53: p. 882-8.

-

7

Prevalence and prognostic factors of disability after childhood injury

Suzanne Polinder, Willem Jan Meerding , Hidde Toet, Saakje Mulder,
Marie-Louise Essink-Bot, Ed F. van Beeck

Pediatrics. 2005; 116: 810-817

Abstract

Objective To assess the prevalence and the prognostic factors of disabilities after minor and major childhood injuries, and to analyze what sociodemographic and injury related factors are predictive for sub-optimal functioning in the long term.

Method We conducted a patient follow-up study in a stratified sample of 1221 injured children who were aged 5 to 14 years and had visited an emergency department in the Netherlands. Postal questionnaires were sent 2½, 5 and 9 months after the injury. We gathered injury and external cause data, sociodemographic information, and data on functional outcome with a generic health status measure EuroQol (EQ-5D) with an additional cognitive dimension and the visual analog scale. The data were adjusted for nonresponse and the sample stratification. We performed bootstrap analysis to estimate the prevalence of disability in terms of the EQ-5D summary score and the occurrence of limitations in separate health domains: mobility, self-care, usual activities, pain/discomfort, anxiety/depression and cognition. We analyzed the relationship between functional outcome and sociodemographic and injury-related determinants by logistic regression analysis.

Results Response rates with respect to the original sample were 43%, 31% and 30%, respectively. A total of 37% of the children were admitted to the hospital. The mean age of the children was 9.6 years. In two thirds (65%) of the cases, the injury was attributed to a home and/or leisure injury. The health status of injured children improved from 0.92 (EQ-5D summary score) at 2½ months to 0.96 at 5 months and 0.98 at 9 months. Of all injured children, 26% had at least 1 functional limitation after 2½ months, 18% after 5 months and 8% still experienced functional limitations after 9 months. After 2½ months, lower extremity fractures and other injuries (eg, spinal cord injury, injury of the nerves) demonstrated the worst functional outcome. Independent of the type of injury, our sample of injured children generally showed good recovery between 2½ and 9 months. The highest prevalence of dysfunction after 9 months existed for pain/discomfort (7%) and usual activities (5%). Hospital admission (odds ratio: 3.6–5.8) and female gender (odds ratio: 3.0) were predictive for long-term disability. Girls reported more problems for all health domains (except self-care) compared with boys after 9 months. Almost one fifth of injured children with a hospital stay of > 3 days still had pain and problems with usual activities 9 months after the injury. Three quarters of all residual problems were caused by nonhospitalized injuries.

Conclusion Most children show quick and full recovery after injury, but a small subgroup of patients (8%) has residual disabilities after 9 months. Girls have a 3-fold risk compared with boys for long-term disability after childhood injury. Prognosis in the long-term is also negatively influenced by hospitalization, but in absolute terms, residual disabilities are frequently caused by injuries that are treated fully in the emergency department. The group of injured children with persistent health problems as identified in this study indicates the importance of health monitoring over a longer period in trauma care, whereas trauma care should be targeted at early identification and management of the particular needs of these patients.

Introduction

Injury has been widely recognized as a major public health problem, and is the leading cause of death and morbidity among children in high-income countries [1, 2]. Information on both short- and long-term functional outcome of injury and its major determinants demonstrates specific health consequences of different injuries and helps to identify patients who are at risk for severe or permanent disability. It therefore contributes to the evaluation and further improvement of preventive interventions and trauma care for children. Because of the considerable variety in functional consequences and recovery patterns of injuries, a uniform measurement of disability is a necessary and challenging task. Generic instruments thereby enable a uniform comparison of injuries among each other and with other health problems.

Several studies on the health consequences of injuries have been done before [3-6]. However, functional outcome in children has received little or no attention [7]. Assessment of patient outcome after injury for children so far has focused mainly on the psychological effects [8-10], or only on the most severely injured trauma patients, including children with traumatic brain injury [11-15]. Few studies have described the impact of injuries on the health status of children with both minor and major injuries over time with a generic quality of life measure [7, 16].

This chapter describes a large follow-up study in injured children who were aged 5 to 14 years and had visited an emergency department in the Netherlands. This study is an extension of an earlier performed follow-up study on functional outcome of injured persons aged 15 years and older with a similar design, as described in chapter 6 [17]. It provides uniform data on the levels of functioning and disability at three points in time until 9 months after injury, which gives information about the recovery pattern of children. We aimed to answer the following questions: a) What is the functional outcome in children 2, 5 and 9 months after injury? b) Which socio-demographic and injury related factors are predictive for sub-optimal functioning in the long term?

Data and methods

Study population and follow-up

We conducted a patient follow-up study among 1221 injured children who were aged 5 to 14 years and had visited 1 of the emergency departments (EDs) of the Dutch Injury Surveillance System (LIS) between October 8, 2001 and December 31, 2002. LIS has been implemented in 17 hospitals in the Netherlands (15% coverage), in which all unintentional and intentional injuries are recorded. These hospitals are geographically spread across the country and are regarded to be representative of the total population. Our study sample was stratified so that severe, less common injuries were overrepresented. Postal questionnaires were sent 2½, 5 and 9 months after the injury.

When the child was younger than 13 years, the parents were asked to complete the questionnaire, when possible together with the child. All hospitals gave permission for the study before the questionnaires were fielded. For privacy reasons, the first questionnaire was made anonymous. For the second and third questionnaires, the patients and their parents needed to give permission by an informed consent form. Nonresponders on the second and third questionnaires received a reminder to increase response rates. The questionnaire was designed to collect information on functional outcome, sociodemographic and injury-related characteristics and health care use.

Functional outcome

In this study the generic EuroQol (EQ-5D) classification of health [18] was used to measure health status because it is simple and takes only 2 minutes to complete; this could allow routine collection of these data in the future [19]. We selected the EQ-5D because it covers the main health domains that are affected by injury. It is well able to describe a heterogeneous injury population and to discriminate among specific injuries [17]. Moreover, the EQ-5D has been recommended for (economic) evaluation of trauma care at a consensus conference [20]. Earlier research has established the feasibility and validity of the EQ-5D for children in the age of 5 to15 years [21, 22]. In this classification, health is defined along five dimensions: mobility, self-care, usual activities, pain / discomfort and anxiety / depression. Each dimension has 3 levels: no problem, moderate problem, or severe problem. In the second part of the EuroQol instrument, respondents rate their own health state on a visual analog scale (VAS), between 0 (worst imaginable health state) and 100 (best imaginable health state). In addition, a scoring algorithm based on empiric valuations from the UK general population and subsequent statistical modeling is available by which each health state description can be expressed into a summary score [23]. This summary score ranges from 1 for full health to 0 for death, and can be interpreted as a judgment on the relative desirability of a health status compared with perfect health. Because the EQ-5D classification does not inform memory patterns and / or ability to concentrate, an item was added on cognitive ability [24].

Socio-demographic and injury related characteristics

Potential determinants of health status can be grouped into sociodemographic (age and gender) and injury-related characteristics (type of injury, external cause, multiple injury, admission to hospital and length of stay). Injury-related factors could be regarded as proxy indicators of injury severity. The type of injury was picked from the LIS, in which up to 3 injuries can be recorded by type and body region. In case of multiple injuries, an algorithm derived from the literature determined the most severe injury [25]. This algorithm gave priority to spinal cord injury over skull/brain injury (except concussions), hip fracture and other lower extremity fractures, respectively. Injuries were classified by location and type into 8 groups, which represent the main injury groups in children. For admitted patients, the diagnosis was verified at the individual level with information from the hospital discharge register (HDR) (International Classification of Diseases, 9th Revision). In discordant cases (8%), the hospital discharge diagnosis replaced the diagnosis from the ED (LIS). The relatively high percentage of discordant cases can be explained, because additional diagnostic information becomes available between admission (LIS) and discharge (HDR). The first-line nature of the ED can result in a "most likely diagnosis" that has to be changed after thorough clinical evaluation. Demographic information was drawn from LIS and was verified by the questionnaire. The prevalence of comorbidity was very low (5%). Therefore, this variable was not addressed specifically in our study.

Statistical analysis

A nonresponse analysis was performed by multivariate logistic regression. We tested age, gender, type of injury, external cause, hospitalization and length of stay, health status (EQ-5D summary score), and ambulance transport as possible determinants of nonresponse. Because response differed between the first, second and third questionnaires, separate nonresponse analyses were conducted for each measurement. All significant variables were used to adjust for response bias. Subsequently, the respondents were weighted with the inverse probability of response resulting from the final model. In addition to the nonresponse correction, the data were adjusted for the sample stratification. The resulting weighted data can be considered representative of a population of children who visited 1 of the EDs in the Netherlands. Additional statistical analyses were performed on the weighted data.

A number of respondents (2½ months: 13%) did not report on 1 or more health domains of the EQ-5D. Because the summary score can be computed only in case of complete information on all health domains, the missing values were estimated by hot-deck imputations, using the reported values of people with similar scores in the health domains that were reported [26]. Sociodemographic and injury-related characteristics were tested as predictors of suboptimal functioning after 9 months in univariate and multivariate logistic regression analyses. They all were entered as categorical variables. Suboptimal functioning was defined as having limitations for at least 1 of the 5 EQ-5D dimensions. The extreme unequal weighting of the data as a result of adjustment for nonresponse stratification could influence the confidence intervals (CIs) of the estimates [27]. To take this problem into consideration, we used bootstrap analysis. This is a resampling technique by which a specified number of population samples are drawn from the data, given the distribution of the population across the variables that are tested. The distribution of the bootstrap replica across the variables gives information about the significance of each variable. We did 500 iterations to test the significance levels of the independent variables. We calculated overall P values using the regression coefficients and covariance matrix resulting from the bootstrap replicas. The results were regarded as significant when the outcomes yielded $P < 0.05$. Logistic regression analysis was used to estimate the relative

Table 7.1 Study population by age, gender, admission and length of stay, external cause, and type of injury for the total study sample and responders (2½ months)

	Total (n=1221)	%	Respondents (%) (n=527)	*P* Value
Age				p<0.05
5-8	437	35.8	38.1	
9-11	342	28.1	30.0	
12-14	442	36.2	31.9	
Sex				n.s.
Boys	696	57.0	56.4	
Girls	525	43.0	43.6	
Hospitalization				p<0.05
Not admitted	784	64.2	62.6	
1-3 days	342	28.0	32.2	
>= 4 days	54	4.4	4.8	
unknown	40	3.3	0.6	
Transport				n.s.
Ambulance transport	215	17.6	18.4	
No ambulance	1002	82.1	80.9	
Unknown	4	0.3	0.7	
Accident category				n.s.
Home and leisure	794	65.0	61.4	
Traffic	177	14.5	15.4	
Sport	233	19.1	21.7	
Intentional	6	0.5	0.7	
Unknown	11	0.9	0.7	
Type of injury				
Head injury	228	18.5	17.5	p<0.05
Facial injury (incl. eye)	60	4.9	4.0	
Upper extremity fractures	404	33.1	40.0	
Lower extremity fractures	156	12.8	14.0	
Dislocation upper / lower extremity	79	6.5	6.8	
Internal organ injury	34	2.8	2.3	
Minor external injuries (incl. burns)	152	12.5	8.5	
Other and unspecified injury [1]	108	8.9	6.8	
Multiple injury				n.s.
1	1070	87.6	88.8	
2	125	10.3	9.3	
>=3	26	2.1	1.9	

n.s. = not significant (significance level 0.05)

[1] 'other injury' consists of spinal cord injury, injury of nerves, whiplash, open wounds, poisoning

risk of the predictors of suboptimal functioning. These relative risks were estimated by odds ratios (ORs) with 95% CIs. The 95% CIs were determined by using the 2.5% lowest and highest percentiles of 500 replicas. An OR of 1 indicates no association. When OR is < 1, the risk is lower than the reference category, and when it is < 1, the risk is higher. The departure from 1 (no association) is statistically significant at the 5% level if the 95% CI does not include 1.

Results

Study population

The questionnaires were sent to 1221 injured children and their parents. We obtained completed first questionnaires on 527 (43%) children, 383 (73% of the responders of the first questionnaire) on the second questionnaire, and 365 (95% of the responders of the second questionnaires) on the third questionnaire. Therefore, response rates with respect to the original sample were 43%, 31% and 30%, respectively. A small percentage (10%) of children who were younger than 12 years completed the questionnaire themselves; in 75% of the cases, their parents completed the questionnaire, and 15% of the children completed it together with their parents. On the first questionnaire, 297 boys and 230 girls (both 43% response rate) responded, 37% of which were admitted to the hospital. The mean age of the children was 9.6 years. In more than half (65%) of the cases, the injury was attributed to a home and/or leisure injury. There were minor differences between respondents and nonrespondents (Table 7.1). Younger patients, hospitalized patients and patients with upper extremity fractures had a somewhat higher response to the first questionnaire ($P < 0.05$). For the second and third questionnaires, children with a relatively good health state (EQ-5D summary score at 2½ months) were less likely to respond ($P < 0.05$).

Functional outcome

The health status of injured children improved from 0.92 (EQ-5D summary score) at 2½ months to 0.96 at 5 months and 0.98 at 9 months (Table 7.2). Hospital admission and the length of hospitalization were negatively related to functioning in both the short term and the longer term, with children who stayed in the hospital for > 3 days having a relatively worse health state at all measurements. After 2½ months, lower extremity fractures and other injuries (e.g. spinal cord injury, injury to nerves, whiplash) demonstrated the worst functional outcome. The relatively high score of head injuries partly reflects that the EQ-5D insufficiently discriminates between injuries with and without cognitive sequelae. Only 5% of children with head injury reported cognitive limitations after 2½ months.
Independent of the type of injury, our sample of injured children generally showed good recovery between 2½ and 9 months. There were no differences found in health state for

Table 7.2 EQ-5D summary score (95% CI) 2½, 5 and 9 months after injury by sociodemographic and injury-related characteristics

	2½ Months		**5 Months**		**9 Months**	
Total	0.92		0.96		0.98	
Sex		n.s.		n.s.		*P* < 0.05
Boys	0.92	(0.88-0.95)	0.97	(0.95-0.98)	0.99	(0.99-1.00)
Girls	0.92	(0.89-0.94)	0.94	(0.91-0.96)	0.95	(0.92-0.98)
Age		n.s.		n.s.		n.s.
5-8	0.93	(0.88-0.96)	0.95	(0.92-0.98)	0.99	(0.98-1.00)
9-11	0.91	(0.84-0.97)	0.96	(0.93-0.98)	0.98	(0.96-1.00)
12-14	0.91	(0.87-0.95)	0.97	(0.94-0.99)	0.97	(0.95-0.99)
Hospitalization		*P* < 0.05		*P* < 0.05		*P* < 0.05
Not admitted	0.92	(0.89-0.95)	0.96	(0.94-0.98)	0.98	(0.97-0.99)
1-3 days	0.86	(0.83-0.89)	0.92	(0.88-0.95)	0.96	(0.92-0.98)
>=4 days	0.79	(0.71-0.85)	0.91	(0.87-0.98)	0.95	(0.91-1.00)
Accident category		n.s.		*P* < 0.05		*P* < 0.05
Home and leisure	0.91	(0.86-0.95)	0.95	(0.93-0.97)	0.98	(0.97-0.99)
Traffic	0.91	(0.86-0.95)	0.95	(0.91-0.97)	0.95	(0.91-0.98)
Sport	0.94	(0.91-0.97)	0.97	(0.94-0.99)	0.98	(0.96-1.00)
Intentional	0.67		0.92		0.94	
Unknown	0.89		1.00		1.00	
Type of injury		n.s.		*P* < 0.05		n.s.
Head injury	0.93	(0.86-0.97)	0.96	(0.89-0.99)	0.97	(0.92-0.99)
Facial injury	0.98	(0.92-1.00)	0.93	(0.86-0.99)	1.00	(0.99-1.00)
Upper extremity fractures	0.92	(0.87-0.96)	0.97	(0.94-0.98)	0.99	(0.97-1.00)
Lower extremity fractures	0.87	(0.82-0.92)	0.95	(0.92-0.98)	0.96	(0.92-0.98)
Dislocation extremity injury	0.91	(0.80-0.98)	0.96	(0.85-0.99)	0.98	(0.92-1.00)
Internal organ injury	0.87	(0.72-0.98)	1.00	(1.00-1.00)	1.00	(1.00-1.00)
Minor external injuries	0.93	(0.83-0.97)	0.97	(0.94-1.00)	0.99	(0.96-1.00)
Other injury [2]	0.80	(0.61-0.95)	0.94	(0.88-0.99)	0.97	(0.92-1.00)
Multiple injury		n.s.		n.s.		n.s.
1	0.92	(0.89-0.94)	0.96	(0.94-0.99)	0.98	(0.96-0.99)
2	0.91	(0.84-0.97)	0.98	(0.91-0.98)	0.98	(0.93-0.99)
>=3	0.79	(0.60-0.93)	0.89	(0.71-0.94)	0.95	(0.86-0.96)

[1] Data are corrected for non-response and stratification and are representative for a population of injured children who visited an ED in the Netherlands. [2] 'other injury' consists of spinal cord injury, injury of nerves, whiplash, open wounds, poisoning. n.s. = not significant (significance level < 0.05)

boys and girls after 2½ months (24% of boys and 26% of girls reported suboptimal functioning), but in the long run, girls (in particular from the age of 10–11 years onward; data not shown) had a significantly worse health state than boys, with an EQ-5D summary score after 9 months of 0.95 for girls compared with 0.99 for boys.
Furthermore, parents valued their children's health better than children themselves (0.93 vs 0.91 after 2½ months). However, no significant association was found between parent proxy report and gender (data not shown).
Of all injured children, 26% had at least 1 functional limitation after 2½ months, 18% after 5 months and 8% of children still reported functional limitations after 9 months. After 2½ months, most limitations were reported for pain/discomfort (22%) and performing usual activities (15%), but also the largest improvements between 2½ and 5 months were reported in these domains (Figure 7.1). After 2½ months, almost 10% of the children reported limitations in mobility and self-care, but after 5 months, none of the children had problems with their usual activity and only a very small group (2%) still reported limitations in mobility. The prevalence of limitations for all health domains decreased in time, except for anxiety/depression, for which higher numbers of limitations were reported after 5 than after 2½ months. After 9 months, most children had recovered from their injury.

In table 7.3 the prevalences of limitations on each EuroQol health domain after 9 months are presented by sociodemographic and injury-related characteristics. The highest prevalences of disability existed for pain/discomfort (7%) and usual activities (5%).

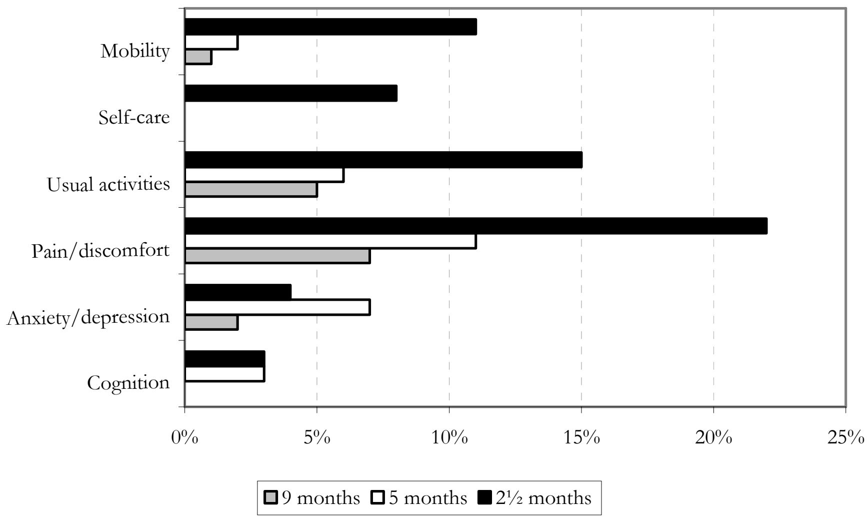


Figure 7.1 Prevalence of limitations (moderate or severe) of the EQ-5D health domains by time interval (%). Data are corrected for nonresponse and stratification and are representative of a population of injured children who visited an ED in the Netherlands.

Table 7.3 Prevalence of moderate or severe problems in the EQ-5D health domains and cognitive ability (in %) and mean EQ-5D summary measure and VAS by sociodemographic and injury-related characteristics (9 months)

	Mobility	Self-care	Usual activities	Pain, discomfort	Anxiety, depression	Cognition	EQ-5D sum score	VAS
Total	1.4	0.0	4.6	6.8	2.2	0.4	0.98	93
Sex								
Boys	0.1	0.0	1.0	2.5	0.7	0.3	0.99	95
Girls	4.1	0.0	12.2	15.7	5.4	0.7	0.95	89
Age								
5-8	1.0	0.0	1.6	2.7	1.1	0.9	0.99	92
9-11	0.5	0.2	5.3	6.0	4.8	0.5	0.98	96
12-14	2.3	0.0	6.9	11.0	1.7	0.2	0.97	92
Hospitalization								
Not admitted	1.4	0.0	4.3	6.4	2.0	0.2	0.98	93
1-3 days	6.7	0.3	6.5	16.1	3.4	4.1	0.96	92
>=4 days	7.1	2.6	15.0	16.6	13.5	10.6	0.94	88
Accident category								
Home and leisure	0.7	0.1	2.6	5.4	2.4	0.4	0.98	94
Traffic	4.6	0.0	7.9	15.1	3.7	1.7	0.95	92
Sport	1.0	0.0	7.1	7.0	0.7	0.1	0.98	93
Intentional	15.6	0.0	15.6	15.6	15.6	0.0	0.94	93
Type of injury								
Head injury	5.3	0.4	6.6	7.3	7.8	1.4	0.97	92
Facial injury	0.0	0.0	0.2	0.2	0.4	0.0	1.00	99
Upper extremity fractures	0.0	0.0	3.8	3.9	3.4	0.1	0.99	95
Lower extremity fractures	9.9	0.0	5.9	11.8	1.6	0.5	0.95	91
Dislocation extremity injury	2.6	0.0	5.3	8.0	0.9	0.5	0.98	94
Internal organ injury	0.0	0.0	0.0	0.0	0.0	0.0	1.00	96
Minor external injury	0.0	0.0	4.8	5.0	0.0	0.0	0.99	87
Other injury[1]	0.0	0.0	9.6	28.0	3.1	2.9	0.94	94
Multiple injury								
1	1.6	0.1	4.9	7.4	0.1	0.4	0.98	93
2	0.5	0.0	6.4	7.8	0.0	0.0	0.98	88
>=3	0.0	0.0	20.0	0.0	0.0	25.8	0.95	85

[1] Consists of spinal cord injury, injury of nerves, whiplash, open wounds, poisoning

Girls reported more problems for all health domains (except self-care) compared with boys, which was also confirmed by the VAS score for self-related health (89 compared with 95). Children with head injury reported relatively high prevalences of limitations on usual activities, pain/discomfort and anxiety/depression. Children with lower extremity fractures reported relatively high prevalences of limitations on mobility and pain/discomfort and children with other injury reported a very high prevalence for pain. A high percentage of children with multiple injuries reported problems with usual activities and cognition 9 months after injury. Furthermore, we found an increase in levels of pain/discomfort and in limitations of usual activities by age. Almost one fifth of the children who had been admitted to the hospital for > 3 days still reported problems with usual activities and pain/discomfort after 9 months.

Nine months after the injury, 8% of the children still had functional limitations for at least 1 EQ-5D dimension. Hospitalization was a significant and independent predictor for long-term disability (Table 7.4). Girls had a 3 times higher chance for suboptimal functioning in the long term than boys, which reached significance after adjustment for hospitalization (adjusted OR: 3.0). The other variables did not show significant associations with functional outcome in the long term. Because of their 3-fold risk of suboptimal functioning, girls (54%) outnumber boys (46%) in the group with residual disabilities at 9 months. Despite the increased risk for a bad functional outcome among injury patients who were admitted to the hospital, 74% of children with residual disabilities had not been hospitalized.

Discussion

The vast majority of injured children reported a good health status already within 3 to 5 months after the injury and almost every child has fully recovered after 9 months. Of all injured children, 26% had at least 1 functional limitation after 2½ months, 18% after 5 months and a group of 8% of children still reported functional limitations after 9 months. After 9 months, the highest levels of dysfunction existed for pain/discomfort (7%) and usual activities (5%). Female gender and hospitalization were significant and independent predictors for long-term disability. Hospitalized children had a 3- to 5-fold risk for suboptimal functioning in the long term compared with nonadmitted children. Almost one fifth of injured children who stayed in the hospital for > 3 days still have pain and problems with usual activities after 9 months. Girls had a 3-fold risk for showing at least 1 functional limitation in the long term, compared with boys and had higher prevalences of disability in all health domains.

The strength of our study is that it contributes to the empirical knowledge about the health status of a comprehensive group of injured children over time and differences herein by sociodemographic factors and types of injury. We deliberately included minor

Table 7.4 Unadjusted and adjusted ORs for suboptimal functioning 9 months after injury by key indicators (gender, age, hospitalization, external cause, injury type, multiple injury)

Determinants	Patients (%) [1]	Unadjusted OR (95% CI)	Adjusted OR (95% CI) [2]
Sex			*P < 0.05*
Boy	46	1	1
Girl	54	2.9 (1.0-9.9)	3.0 (1.0-11.0)
Age			
5-8	24	1	1
9-11	18	2.1 (0.6-10.5)	0.3 (0.1-1.0)
12-14	58	2.4 (0.7-10.5)	0.4 (0.1-1.6)
Hospitalization		*P < 0.05*	*P < 0.05*
Not admitted	74	1	1
1-3 days	23	5.4 (1.4-17.2)	5.8 (1.3-20.9)
>= 4 days	3	3.1 (1.2-14.7)	3.6 (1.1-18.9)
External cause			
Traffic injury	15	2.4 (0.8-7.4)	2.0 (0.6-6.7)
Other injury	85	1	1
Type of injury			
Head injury	10	2.9 (0.0-138.2)	2.1 (0.4-130)
Facial injury	11	2.1 (0.0-19.3)	1.7 (0.0-20.1)
Upper extremity fractures	25	1.5 (0.0-72.6)	1.3 (0.1-65.3)
Lower extremity fractures	11	3.4 (0.04-101.6)	2.7 (0.5-89.2)
Dislocation extremity injury	10	3.0 (0.0-72.6)	3.1 (0.4-74.3)
Internal organ injury	1	0.1 (0.0-1.0)	0.0 (0.0-0.6)
Minor external injuries	12	1	1
Other injury [3]	20	7.1 (0.8-2021.6)	6.0 (0.5-1971.6)
Multiple injury [4]			
1	95	1	1
2	5	5.9 (0.1-19.0)	2.2 (0.1-17.5)

Suboptimal functioning was defined as having limitations for at least 1 of the 5 EQ-5D dimensions.
[1] Percentage of patients after correction for nonresponse and stratification. [2] ORs are adjusted for hospitalization (gender, age, external cause, type of injury, multiple injury) or gender (hospitalization). [3] Consists of spinal cord injury, injury of nerves, whiplash, open wounds, poisoning. [4] Only 1 patient with 3 injuries had limitations after 9 months, with an OR of 11 (0.0 –29.8).

injuries and nonhospitalized children in our study. Our study shows that minor (nonhospitalized) injuries cause three quarters of all residual impairments and disabilities. Thus far, this large group of ED attendees with minor or moderate injuries has received little attention. A major limitation of our study was the relatively low response.

From the original study sample of injured children who had visited an ED, 43%, 31% and 30% were still included after 2, 5 and 9 months, respectively. This is attributable largely to the use of postal questionnaires, because we were limited in the use of response-increasing incentives. Because of privacy reasons, it was not feasible to use reminders for the first questionnaire, but we did so for the second and third questionnaires. However, we had much background information about the nonrespondents and adjusted the data for nonresponse bias after an extensive analysis in which the impact of patient and injury-related factors were investigated. Moreover, most differences between responders and the original study sample were not substantial.
Another important issue to be discussed is that most of our data on functional outcome of childhood injuries were obtained from parent reports. There is substantial debate in the health outcomes literature about the most appropriate respondent when assessing children's health [28]. First, children's self-report may be theoretically preferable because it is consistent with the subjective nature of the EuroQol (made for self-completion), and evidence is emerging that children are able to provide accurate and reliable information concerning their health status [7]. Hennessy and Kind [29] argued that it is at least possible to use the EQ-5D for self completion with a school-aged population (12-18 years). Particularly younger children are not able to provide reliable information on abstract, health-related concepts [30]. Only a small group of children (10%) who were younger than 12 years completed the questionnaire themselves. Second, functional outcomes may differ after completion of the EQ-5D by child or parent [31]. An advantage of using parents as proxy reporters is that adults can generally be expected to provide more reliable responses on more complex, psychologically oriented measures. The literature mentions that parental reports may overestimate the child's functioning, especially when assessing the physical functioning [7]. This can also be confirmed by our research outcomes, since parents valued their children's health better than children themselves (0.93 compared to 0.91 after 2½ months). The higher prevalence of disability of girls in the long term is not influenced by parent proxy reports. For both, boys and girls, the parents reported a worse health state than the children themselves. The parents may realize that the injury could have resulted in a worse outcome, and that, with respect to the initial injury, their child is doing well [7]. Although the exact values between child and adult might be different, previous research suggest that at least the ranking order largely will be the same [21].

We compared our estimates with EuroQol data from a Dutch study of children in the general population, who found a mean EQ-5D summary score of 0.92 for children (age 5-15 years) [21]. Two months after the injury, the mean summary score for the health state of nonhospitalized patients with childhood injuries (EQ-5D: 0.92) was similar to the general population's health when measured by the EQ-5D summary score. Five and 9 months after the injury, the mean health state of both nonadmitted and admitted patients with childhood injuries was slightly higher than the health state in the general population (0.96 and 0.98, respectively, vs 0.92). For the children in our study, we only found a small increase in average health status between 5 and 9 months (EQ-5D: 0.96 vs 0.98). A

possible explanation therefore could be that a significant number of children have achieved their maximum level of functioning after 5 months, leaving no room for additional improvement [17]. Furthermore, as a result of a temporally worse health state at the time after the injury, people might judge their later health state more positive than before the injury, since their frame of reference has changed (response shift) [32].
Caution is needed when the potential clinical relevance of changes in the EQ-5D summary score is considered. The EQ-5D is a valuable instrument to study differences and changes in health status after injury at the population level, but small differences and changes at the level of an individual child can be interpreted only if the scores on the separate EQ dimensions and additional clinical data (eg, chart data, medical examinations) are taken into account as well.
An important finding in our study is that most children demonstrate a quick recovery after an injury: 3 out of 4 children were fully recovered after 2½ months. Other studies also found that young injury victims reported a reasonably good long-term health state [7, 33]. Aitken et al [16] studied the health state of children after admission for an injury with the child health questionnaire and found that after 6 months 28% of children reported some limitations, which is somewhat higher than the 21% of admitted children with limitations after 5 months resulting from our research. Because the child health questionnaire measures health over 14 domains, it might be more sensitive for limitations than the EQ-5D, which possibly explains the higher prevalence of limitations.
A previously performed follow-up study in the Netherlands about functional outcome of injured patients aged 15 years and older [17] also gives uniform information on the levels of functioning and disability in the first 9 months after injury. We observed a better health status for children below 15 years for all three measurements compared with adults. Earlier research also showed a significant negative association of age and the EQ-5D summary measure, indicating better recovery at younger ages [34].
Whereas the incidence of injuries is higher in boys than in girls, injured girls demonstrate more limitations in the long term. Girls reported more problems for all health domains (except self-care) than boys. Research among adult injury victims also found that female gender was independently associated with worse functional outcome in the United States [35] and the Netherlands [17, 19]. We demonstrated that this also applies to children. This finding cannot readily be explained, but it has been hypothesized that physiologic, psychological, and social differences may influence this association [19]. Residual pain, in particular, was much more frequent in girls (16%) than in boys (3%). Our findings stress the importance of more research into gender differences in injury outcomes, including the development of pain syndromes [36].

We conclude that the present study gives important insight into levels of functioning and recovery patterns across types of injury and major sociodemographic variables. The proportion of children in the age of 5 to14 years who annually visits an emergency department in the Netherlands is 9% (179,000 Dutch children in 2004) [37]. On the basis of our current study results, we may conclude that most of these children recover quickly from an injury but that each year, again a considerable group of children (0.6%; 12,500 Dutch children in 2004) experience functional limitations as a result of an injury in the long term. The group of injured children with persistent health problems as identified in this study indicates the importance of health monitoring over a longer period in trauma care, whereas trauma care should be targeted at early identification and management of the particular needs of these patients.

References

1. Danseco, E.R., T.R. Miller, and R.S. Spicer, Incidence and costs of 1987-1994 childhood injuries: demographic breakdown. Pediatrics, 2000. 105(2): p. 1-8.
2. Krug, E.G., G.K. Sharma, and R. Lozano, The global burden of injuries. Am J Public Health, 2000. 90: p. 523-6.
3. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. J Trauma, 2000. 48(5): p. 851-850.
4. Holbrook, T.L. and D.B. Hoyt, The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. J Trauma, 2004. 56(2): p. 284-90.
5. MacKenzie, E.J., B.M. Cushing, G.J. Jurkovich, M. J.A., et al., Physical impairment and functional outcomes six months after severe lower extremity fractures. J Trauma, 1993. 34: p. 528-538.
6. Ponzer, S., B. Bergman, B. Brismar, and L.M. Johansson, A study of patient-related characteristics and outcome after moderate injury. Injury, 1996. 27: p. 549-555.
7. Sturms, L.M., C.K. van der Sluis, J.W. Groothoff, H.J. ten Duis, et al., Young traffic victims' long-term health-related quality of life: child self-reports and parental reports. Arch Phys Med Rehabil, 2003. 84(3): p. 431-6.
8. Stallard, P., R. Velleman, and S. Baldwin, Prospective study of post-traumatic stress disorder in children involved in road traffic accidents. BMJ, 1998. 317: p. 1619-23.
9. Ellis, A., G. Stores, and R. Mayou, Post-traumatic stress disorder in children and adolescents following road traffic accidents. Br J Psychiatry, 1998. 172: p. 443-7.
10. Kassam-Adams, N. and F.K. Winston, Predicting child PTSD: the relationship between acute stress disorder and PTSD in injured children. J Am Acad Child Adolesc Psychiatry, 2004. 43: p. 403-11.
11. Wesson, D.E., J.I. Williams, L.J. Spence, R.M. Filler, et al., Functional outcome in peadiatric trauma. J Trauma, 1989. 29: p. 589-592.
12. Harris, B.H., S.D. Schwaitzberg, T.M. Seman, and C. Hermann, The hidden morbidity of pediatric trauma. J Pediatr Surg, 1989. 24: p. 103-106.
13. Tursz, A. and M. Crost, Sequelae after unintentional injuries to children: an exploratory study. Injury prevention, 2000. 6: p. 209-213.
14. Stancin, T., D. Drotar, H.G. Taylor, K.O. Yeates, et al., Health-related quality of life of children and adolescents after traumatic brain injury. Pediatrics, 2002. 108: p. E34.
15. Yeates, K.O., K. Armstrong, J. Janusz, H.G. Taylor, et al., Long-Term Attention Problems in Children With Traumatic Brain Injury. J Am Acad Child Adolesc Psychiatry, 2005. 44: p. 574-84.
16. Aitken, M.E., J.M. Tilford, K.W. Barrett, J.G. Parker, et al., Health status of children after admission for injury. Pediatrics, 2002. 110: p. 337-342.
17. Meerding, W.J., C.W. Looman, M.L. Essink-Bot, H. Toet, et al., Distribution and determinants of health and work status in a comprehensive population of injury patients. J Trauma, 2004. 56(1): p. 150-61.
18. EuroQol: a new facility for the measurement of health-related quality of life-the EuroQol Group. Health Policy, 1990. 16: p. 199-208.

19. Vles, W.J., E.W. Steyerberg, M.L. Essink-Bot, E.F.v. Beeck, et al., Prevalence and determinants of disabilities and return to work after major trauma. J Trauma, 2005. 58: p. 126-135.
20. Bouillon, B., H.J. Kreder, E. Eypasch, T.L. Holbrook, et al., Quality of life in patients with multiple injuries--basic issues, assessment, and recommendations. Restor Neurol Neurosci, 2002. 20(3-4): p. 125-34.
21. Stolk, E.A., J.J.V. Busschbach, and V. T., Performance of the EuroQol in children with imperforate anus. Quality of Life Research, 2000. 9: p. 29-38.
22. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. The journal of Trauma: infection, and critical care, 2000. 48(5): p. 851-850.
23. Dolan, P., Modeling valuations for EuroQol health status. Med Care, 1997. 35: p. 1095-1108.
24. Krabbe, P.F.M., M.E.A. Stouthard, M.L. Essink-Bot, and G.J. Bonsel, The effect of adding a cognitive dimension to the EuroQol multiattribute health-status classification system. J Clin Epidemiol, 1999. 52: p. 293-301.
25. MacKenzie, E.J., J.H. Siegel, S. Shapiro, M. Moody, et al., Functional recovery and medical costs of trauma: an analysis by type and severity of injury. J Trauma, 1988. 28: p. 281-297.
26. Rubin, D.B. and N. Schenker, Multiple imputation in health-care databases: an overview and some applications. Stat Med, 1991. 10: p. 585-598.
27. Research Triangle Park, SUDAAN Survey Data Analysis Software, S. BV, Editor. 1993, NC: Research Triangle Institute.
28. Eiser, C. and R. MOrse, Can parents rate their child's health-related quality of life? Results of a systematic review. Qual of Life Res, 2001. 10: p. 347-357.
29. Hennessy, S. and P. Kind, Measuring health status in children: developing and testing a child-friendly version of EQ-5D. 2002, Outcomes Research Group, Centre for Health Economics, University of York.
30. Secnik, K., L. Matza, S. Mannix, and F.R. Sallee, Use of the EQ-5D proxy version in a sample of partners who have children diagnosed with attention deficit/hyperactivity disorder (ADHD). EQ-5D, 2003: p. 23-32.
31. Petrou, S., Methodological issues raised by preference-based approaches to measuring the health status of children. Health Economics, 2003. 12: p. 697-702.
32. Jansen S.J., Stiggelbout A.M., Nooij M.A., Noordijk E.M., et al., Response shift in quality of life measurement in early-stage breast cancer patients undergoing radiotherapy. Qual Life Res, 2000. 9: p. 603-615.
33. Elvik, R., The validity of using health state indexes in measuring the consequences of traffic injury for public health. Soc Sci Med, 1995. 40(10): p. 138501398.
34. Gofin, R., B. Adler, and T. Hass, Incidence and impact of childhood and adolescent injuries: a population-based study. J Trauma, 1999. 47(1): p. 15-21.
35. Holbrook, T.L. and D.B. Hoyt, The impact of major trauma: quality-of-life outcomes are worse in women than in men, independent of mechanism and injury severity. J Trauma, 2004. 2: p. 284-90.
36. Fillingim, R.B., Sex, gender, and pain: women and men really are different. Curr Rev Pain, 2000. 4: p. 24-30.
37. Polinder, S., W.J. Meerding, H. Toet, M.E. Baar, et al., A surveillance bases assessment of medical costs of injury in Europe: phase 2. 2004, Consumer and Safety Institute: Amsterdam.

8

Assessing the burden of injury in six European countries

Suzanne Polinder, Willem Jan Meerding, Saakje Mulder, Eleni Th. Petridou, Ed van Beeck, & EUROCOST reference group

Accepted for publication by the Bulletin of the World Health Organization

Abstract

Background To assess injury-related mortality, disability and disability-adjusted life years (DALYs) in six European countries.

Methods Epidemiological data (hospital discharge registers, emergency department registers, mortality databases) were obtained for Austria, Denmark, Ireland, Netherlands, Norway and the United Kingdom (England and Wales). For each country, the burden of injury was estimated in years lost due to premature mortality (YLL), years lived with disability (YLD), and DALYs (per 1000 persons).

Results We observed marked differences in the burden of injury between countries. Austria lost the largest number of DALYs (25 per 1000 persons), followed by Denmark, Norway and Ireland (17–20 per 1000 persons). In the Netherlands and United Kingdom, the total burden due to injuries was relatively low (12 per 1000 persons). The variation between countries was attributable to a high variation in premature mortality (YLL varied from 9–17 per 1000 persons) and disability (YLD varied from 2–8 per 1000 persons). In all countries, males aged 25–44 years represented one third of the total injury burden, mainly due to traffic and intentional injuries. Spinal cord injury and skull–brain injury resulted in the highest burden due to permanent disability.

Conclusions The burden of injury varies considerably among the six participating European countries, but males aged 15–24 years are responsible for a disproportionate share of the assessed burden of injury in all countries. Consistent injury control policy is supported by high-quality summary measures of population health. There is an urgent need for standardized data on the incidence and functional consequences of injury.

Introduction

Injuries are a major cause of morbidity and mortality in developing and in industrialized regions [1, 2]. Rational choices for injury prevention need to rely on comparable indicators relating the burden of injury to other diseases, and determining the most prevailing and incapacitating types of injury. Summary measures of population health, such as the disability-adjusted life year (DALY) are designed for the comparative analysis of burden [3]. The value of the DALY as a tool for health policy and planning purposes has been increasingly recognized [4]. The DALY combines information on premature mortality and disability due to non-fatal health outcomes. It is a so-called 'health gap measure' of which the quantitations can be interpreted as the gap between the current population health status and an ideal situation in which everyone would live into old age free of disease and disability [5]. The DALY was designed to assess the burden of disease beyond mortality and was aimed for national and international health policies, to develop unbiased epidemiological assessments for major disorders, and to provide an outcome measure that could also be used for cost–effectiveness analysis [6].

The human impact of injury in terms of DALYs in the World Health Organization (WHO) European Region by country, age, sex, injury type and external cause has been very little studied. Expected variation in the burden of injury among the European countries may be due to differences in exposure, injury risk and type of sustained injury, differences in demography, (socio)economic and cultural factors, safety technology, injury-prevention strategies, and the effectiveness of trauma care. Assessment of the variation and its constituent components can be used to identify high-risk groups in Europe and in specific countries and to prioritize injury-prevention programmes.

We aimed to assess the burden of injury—expressed in the summary measure of DALYs and its constituent components, namely premature mortality (years of life lost, YLL) and years lived with disability (YLD)—in six European countries. Data collection and analysis were done within a European collaborative effort, the EUROCOST project. Comparative data on medical costs of hospitalized injury patients in Europe, based on the same incidence data, were published elsewhere [7].

Materials and methods

General approach

We compared the number of lost DALYs attributable to unintentional and intentional injuries in the following European countries: Austria, Denmark, Ireland, Netherlands, Norway and the United Kingdom (England and Wales). Comparable data sources in other European countries were either unavailable or could not be collected and analysed within the framework used. We used two primary data sources: hospital discharge registers with full national coverage to estimate the hospitalization rate and emergency-

department (ED) surveillance systems (both for the year 1999) for the incidence of non-admitted ED patients [7-9]. Since ED systems did not have nationwide coverage, country-specific extrapolation factors were used to extrapolate the ED incidence for the respective types of injury by country towards national level. For Ireland, the Netherlands, and the United Kingdom (UK), this extrapolation was based on the number of ED visits and hospital admissions recorded in ED systems as a proportion of ED visits and hospital admissions in national statistics. In Austria, Denmark and Norway, population data by age and sex from the catchment areas of participating hospitals were used to extrapolate ED surveillance data to national level [8, 9]. To adjust for differences in the demographic composition of the countries, incidence rates were standardized for age (5-year age groups) and sex, using the direct method of standardization.
We computed YLL using a standard life table [4, 10]. YLD were obtained by multiplying frequency, duration and injury-specific severity weights of the injury. DALYs were the summation of YLLs and YLDs [3].

Incidence of non-admitted and admitted patients and mortality data

We used the International Classification of Disease codes 800 to 999 (ICD, 9th revision) [11] and corresponding codes of ICD-10 for countries that used this revision to select and classify both unintentional and intentional injuries. We excluded 'misadventures to patients during surgical and medical care' (ICD-9 E996–999, E870–E876), 'surgical and medical procedures as the cause of abnormal reaction of patients or later complication, without mention of misadventure at the time of procedure' (ICD-9 E878–E879), 'drugs, medicaments and biological substances causing adverse effects in therapeutic use'(ICD-9 E930–E949), and late effects of injury (ICD-9 E905–E909), since these injuries are not usually included in the domain of injury prevention [12].

Table 8.1 Incidence and mortality due to injury in 1999 per country: absolute numbers and rates per 1000 persons

Country	Absolute numbers			Per 1000 inhabitants		
	Incidence		Deaths[c]	Incidence		Mortality rate[c]
	Not-admitted ED[a] patients	Hospitalized patients[b]		Not-admitted ED[a] patients	Hospitalized patients[b]	
Austria	483 269 [d]	187 225	8 798	39.6 [d]	21.7	1.9
Denmark	650 125 [e]	99 618	6 824	115.1 [e]	15.4	4.0
Ireland	115 696 [d]	58 196	3 206	23.7 [d]	12.5	2.0
Netherland	110 0455 [f]	102 768	10 378	63.6 [f]	5.2	1.9
Norway	417 309 [f]	66 962	4 962	79.7 [f]	12.9	3.3
England	5 755 936 [d]	632 179	33 078	105.0 [d]	9.1	1.3
Wales	323 606 [f]	48 266		97.3 [f]	12.3	

[a] ED = Emergency department; data extrapolated. [b] Data from hospital discharge registers. [c] Data from World Health Organization Mortality Database. [d] Home and leisure injury data included. [e] Unintentional injury data included. [f] All injury data included.

Table 8.1 provides an overview of the data by country. Non-hospitalized injury patients included in the study were derived from ED systems, while hospitalized patients were derived from hospital discharge registers. Data on repeated hospitalizations of the same individual were only available from the hospital discharge registers systems of Austria, Norway and the Netherlands, where 0.7%, 8.6%, and 2.6% respectively of hospitalized patients were readmitted patients. This will lead to an overestimate of the incidence and burden of injury. Also it was not feasible to standardize for the quality of health care, a major determinant of disability due to injuries. For the Netherlands, Norway and Wales, the ED surveillance system comprised all types of injuries, while for Denmark it was confined to all unintentional injuries and for Austria, Ireland and England only to home and leisure injuries. Home and leisure injuries account for 70–78% of ED visits for the three countries with all injury data available.
For the mortality data, we used age- and sex-specific death rates from the WHO mortality database for the year 1999 [13]. These data included information on the external cause, while information on injury diagnosis (Appendix 8.A) is not usually available.

Years lived with disability (YLD)

The number of years lived with disability is obtained by multiplying the incidence of cases of injury (both hospitalized and non-admitted ED) by the average duration of the recovery, based on the weights per injury group as recommended in the global burden of disease (GBD) study, performed at the request of WHO, and by a disability weight. Disability weights are valuations that represent the severity of health status associated with specific diseases and injuries [3]. The GBD weights and our data sources were compatible for thirty-three injury groups (Appendix 8.A). Burns were excluded from the analyses since our data were not specific about the percentage surface area burned and/or severity of the wounds, while available data on recovery duration and disability are specific for wound severity. Concussions, whiplash, and superficial injury have an unknown disability weight. For these patients no YLD could be calculated.
The GBD determined a comprehensive set of short-term (first year after injury) and lifelong sequelae. It is assumed that not-admitted ED patients only suffered short-term disability. For hospitalized patients, the GBD formulated injuries with lifelong disability for at least a predefined proportion of the total admitted patients (skull–brain injury, 15%; spinal cord injury, 100%; injury of the nerves, 100%; amputations of the lower and upper extremity, 100%; fracture hip, 5%; and fracture femur shaft, 5%) [3]. Durations of permanent disability were estimated by multiplying the incidence by the age- and sex-specific life expectancies, derived from the standard life table used in the GBD study (West Level 26 life-table) [3]. Because the majority of patients with eye injury in industrialized countries have only minor temporary problems, we adopted the assumption of the Australian burden of disease study [14], which used the short-term disability weight of open wounds for eye injury. Lastly, to avoid double counting with the YLL, the fraction of hospitalized injury patients who died in hospital was excluded from the YLD calculations.

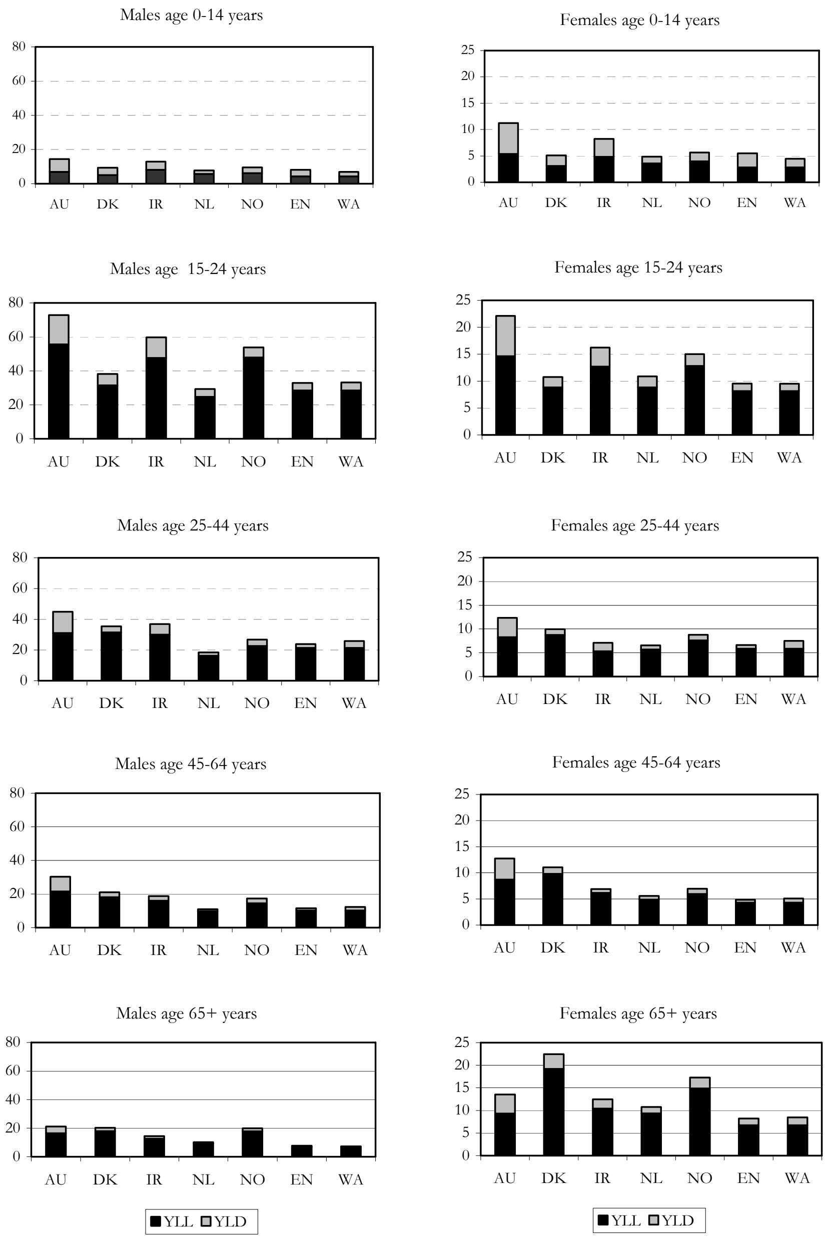


Figure 8.1 The burden of injury as DALYs per 1000 persons, divided into YLD [a] and YLL [b], by age, sex and country

Note: the scale of the *y*-axis differs for males and females. [a] YLD = Years lived with disability. [b] YLL = Years lost through premature mortality. AU = Austria. DK = Denmark. IR = Ireland. NL = Netherlands. NO = Norway. EN = England, United Kingdom. WA = Wales, United Kingdom.

Table 8.2 Disability, premature mortality, and burden related to injury by country (per 1000 persons)

Country	Disability				Premature mortality	Burden of injury
	YLD [a] Not admitted short term	YLD Admitted short term	YLD Admitted life long	YLD Total	YLL [b]	DALY [c]
Austria	0.2	0.2 [f]	7.7	8.2	17.1	25.3
Denmark	0.4	0.4 [e]	2.8	3.4	15.5	18.9
Ireland	0.1	0.1 [f]	4.1	4.3	15.3	19.6
Netherlands	0.2	0.2 [d]	2.8	3.1	9.4	12.6
Norway	0.3	0.3 [d]	2.6	3.2	14.1	17.2
UK, England	0.3	0.3 [f]	2.0	2.4	9.8	12.2
UK, Wales	0.3	0.3 [d]	2.1	2.5		12.3

[a] YLD = years lived with disability. [b] YLL = years lost due to premature mortality. [c] DALY = disability-adjusted life years. Emergency department 'not admitted' data include: [d] All injury data, [e] Unintentional injury data, [f] Home and leisure injury data.

YLL were calculated from the West Level 26 life-table and estimates of mean age at death by age groups (standard life expectancy at birth, 80.0 years for males and 82.5 years for females) [10]. To yield YLL due to injury, standard YLL were multiplied by mortality rates and population numbers. Age-weights or discounting were not applied in the calculations, because this practice is controversial [8].

Results

DALYs by country

There were marked differences in the burden of injury among the participating European countries (Table 8.2). Austria lost the largest number of DALYs (25 DALYs per 1000 persons) resulting from injuries, followed by Denmark, Norway and Ireland with quite comparable estimates varying between 17 and 20 DALYs per 1000 persons, respectively. In the Netherlands and UK, the total number of DALYs is relatively low (12 DALYs per 1000 persons). The variation in the burden of injury between the countries, as shown in table 8.2, is due to high variation in premature mortality (YLL varies from 9.4 in the Netherlands to 17.1 per 1000 persons in Austria) and in disability (YLD varies from 2.4 in England to 8.2 per 1000 persons in Austria).

In all participating countries, 68–82% of the total burden was caused by premature mortality. The burden due to permanent (lifelong) disability was high compared with temporary (short-term) disability. The total burden of short-term disability of non-hospitalized patients is similar to hospitalized patients, because the number of non-hospitalized patients is much larger.

DALYs by age and sex

Figure 8.1 gives an overview of the total DALYs (separated into YLL and YLD) by age and sex for all participating countries. Males were responsible for 65% of the total injury burden. The highest number of DALYs per 1000 persons is observed in males aged 15–24 years for all countries, which is caused by high premature mortality (YLL). However, males aged 25–44 years have the highest share in the total burden of injury, ranging from 46% in Wales to 24% in the Netherlands and Norway. In this age group, the burden of premature mortality is more than three times higher for males than for females in all countries. There are striking differences in total DALYs due to injuries by age and sex among European countries. Noteworthy is the high burden for children and adolescents in Austria and Ireland, middle-aged persons in Austria, and females above age 65 years in Denmark and Norway. The Netherlands, England and Wales show a relatively low burden of injury across all age groups and for both sexes.

DALYs by external cause

The burden of intentional injuries is predominantly attributable to premature mortality (interpersonal violence and suicide). Traffic injuries lead to considerable morbidity and premature mortality (Figure 8.2). The burden of unintentional non-traffic injury (mainly accidental fall) is for a large part caused by disability because of hip fracture. There exist striking differences in the total DALYs by external cause between the participating countries. Austria has the highest injury burden for all external cause groups, with a relatively high contribution of YLD. The Netherlands and the UK have a low burden across all external causes. Ireland has a high burden of traffic injury for males and females. Males in Ireland also cause a high burden due to intentional injuries, compared with the other countries. In Denmark and Norway, the largest part of the total burden is caused by unintentional non-traffic injuries. Noteworthy is the relatively high mortality caused by non-traffic injuries for females in Denmark. The burden of intentional injury varies between countries, an observation that is mainly attributable to international differences in suicide rates.

YLD by injury group

The injury burden by injury group incorporates disability only, because injury-specific mortality data were not available (Table 8.3). Skull–brain and spinal cord injury resulted in the highest total YLD due to life long disability in a relatively young patient group. Hip fracture resulted in the highest short-term disability, due to a high clinical incidence. The high injury disability in Austria and Ireland, as shown in table 8.2, is mainly caused by a high incidence of skull–brain injury due to traffic accidents in relatively young patients (data not shown).

Table 8.3 Leading injury groups by clinical incidence and disability caused per 1000 persons (ranked by total YLD for short- and long-term disability)

Rank	Injury	Clinical incidence[a]	Disability		
			YLD short-term	YLD lifelong	YLD total
1	Skull–brain	25.1	1.4	85.4	86.8
2	Spinal cord	2.4	[b]	82.6	82.6
3	Amputation upper extremity	27.6	[b]	35.5	35.5
4	Fracture hip	125.9	6.8	23.5	30.4
5	Injury of nerves	5.7	[b]	24.6	24.6
6	Amputation lower extremity	12.9	[b]	22.0	22.0
7	Fracture femur shaft	10.9	0.6	7.6	8.2
8	Fracture knee/lower leg	57.8	1.0	[c]	1.0
9	Vertebral column and spine	19.5	0.7	[c]	0.7
10	Fracture elbow / forearm	41.2	0.7		0.7

[a] From hospital discharge registers. [b] All patients have life long disability. [c] All patients have short-term disability.

Discussion

The differences in the burden of injury are large among the six participating European countries. Austria tops the table with the highest burden, and the Netherlands and the UK are at the bottom. Differences in premature mortality and disability both contribute to the variation in injury burden. In all countries the highest burden is observed among adolescents, and among persons aged 15–64 years the burden of injury for males is about three times higher than for females.
Our study has identified high-risk groups for premature injury-related mortality and/or disability. At the European level, males aged 25–44 years are a major high-risk group, since they cause one third of the total injury burden (mainly because of traffic accidents and intentional injuries) in all participating countries. At the country level, specific combinations of external causes and types of injury deserve special attention. A high incidence of skull–brain injuries resulting from traffic accidents in young people, for example, appears to be one of the factors behind the unfavourable position of Austria in terms of YLD and DALYs.

Our results are mostly in agreement with the corresponding age-adjusted mortality rate based on WHO mortality data (Appendix 8.B). Austria and Ireland present the highest mortality rates among the younger age groups (age 0–24 years), corresponding to the remarkably high YLL and the derivative DALYs for these countries. In contrast, although Denmark is by far the country with the highest injury mortality rate among the elderly (age 65+), this age group contributes only for a small percentage to the estimation of the

all age YLL and DALYS, since the life expectancy of persons in this group is much shorter than that of younger persons. The Netherlands and the UK present the lowest mortality rates in each age group, which is an observation that is in agreement with their relatively low numbers of DALYs.
Our findings for six European countries are similar to those for Australia where males of age 25–44 years also had the highest share in the total burden of injury [14], and the burden of injury is dominated by intentional and traffic injuries.

On several issues, the assessment of the burden of injury and international variation herein needs to be improved. Injury mortality data are considered to be valid, except for the elderly, in whom mortality rates for unclassified injuries vary widely (from 4.9/100,000 for Ireland to 42.0/100,000 population for the Netherlands) and comorbidity is an issue of concern. Therefore, the estimated differences in YLL and DALYs in the elderly should be interpreted with caution. In each country, cause-specific mortality was registered on a regular basis with national coverage, allowing cross-country comparisons by age, sex, and external cause. The availability of injury-specific mortality data (e.g. skull–brain injury, spinal cord injury) should further improve the possibilities to analyse and interpret international variation in YLL.
Incidence data for non-admitted ED patients with traffic and intentional injuries was not available in all participating countries. Although this hampered straightforward international comparisons of short-term YLD, its influence is probably modest, since the majority of the injuries of non-admitted ED patients are home and leisure injuries (75%) [7], and their share in the total burden is low (for most countries, less than 2%). Similarly, uncertainty in the estimates of the number of non-hospitalized injury patients because of the extrapolation of sample data is likely to have a small impact on (international differences in) disability, because this is dominated by long-term disability in hospitalized patients. Therefore, an important target for improvement is the estimate of YLD resulting from lifelong disability, which has been estimated conservatively in this study. In our results the YLD for non-admitted injury patients are underestimated owing to incomplete DALY estimates; for some frequently occurring injuries (concussion, superficial injury), no disability weights were estimated in the GBD study. Among these primarily non-admitted patients, there is a small proportion with long-term disability, which may lead to a high estimate of prevalence of disability owing to high annual numbers of patients [15, 16], and thus results in an underestimation of YLD. Although burns are a very disabling type of injury, they were excluded from our analysis. In the data we used no information was available about severity of the wounds (percentage surface area burned) — which is essential for linking the incidence data to existing data on disability — no valid YLD estimates could be made.
The most important issue, however, with respect to international variation in YLD, seems to be the cross-country comparability of the data on injury incidence. In our study, all injuries were similarly valued for all countries, irrespective of the severity of the injury, differences in health-care systems, and differences in registration practice. However, in

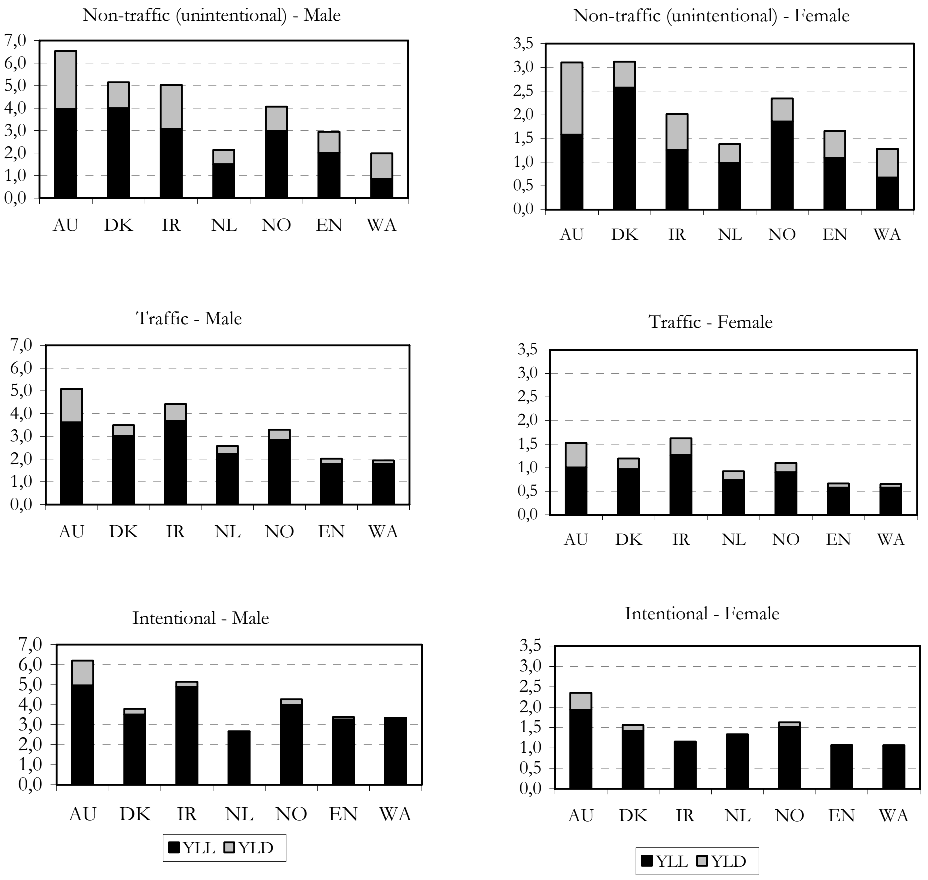


Figure 8.2 DALYs per 1000 persons by external cause, sex and country

chapter 5 we concluded that Austria has a high clinical incidence of injuries of low severity, indicating a low admission threshold [7]. Therefore, in Austria the burden of injury in terms of YLD could be relatively over-estimated. This observation points to the need for international standardization of injury incidence data [9]. Information on injury severity by validated instruments (abbreviated injury scale, AIS; injury severity scale, ISS)[17] for non-hospitalized and hospitalized patients at the ED could support this. Also, good correspondence between the available epidemiological data and disability weights is essential for burden assessment [18], for instance, by standardized data collection about frequency, duration and severity of functional consequences in injury patients [19].

Burden of injury studies are only as good as the weakest link in the chain, which is the epidemiological data [20]. Agenda setting for the collection of epidemiological data is perhaps the most important issue to emerge from our study. Further consideration and development are required to improve the quality of the data collected by routine and standardized methods, and thus indirectly to improve the validity of the measurement of the burden of disease due to injuries. Also, more detailed modelling of incidence, prevalence, mortality and burden for specific injury groups is necessary.

Priorities within international and national health policy will depend on whether the primary aim is an improvement in health care or cost reduction. In an earlier study based on the same data, we estimated medical costs incurred by hospitalized injury patients [7]. We concluded that elderly women (aged 65+ years) consume a disproportionate share of hospital resources for trauma care, mainly caused by hip and femur fractures due to non-traffic injuries. On the basis of our current study, we conclude that males aged 15–44 years with traffic and intentional injuries are an important target for intervention. This demonstrates that health-care costs and the human impact of injury are complementary indicators for national and international health policy. Ideally, costs and burden of injury should be analysed in a combined perspective.

Unintentional and intentional injuries cause 10% of total mortality and account for 16% of DALYs worldwide [1, 21]. However, injuries are remarkably neglected, compared with the attention devoted to research and policy for other leading causes of DALYs worldwide. Our study contributes to a better understanding of the magnitude and characteristics of the problem and can be used for policy priority setting and injury prevention.

References

1. Murray, C.J. and A.D. Lopez, Global mortality, disability, and the contribution of risk factors: Global Burden of Disease Study. The Lancet, 1997. 349(9063): p. 1436-42.
2. Morrison, A. and D.H. Stone, Trends in injury mortality among young people in the European Union: a report from the EURORISC working group. J Adolesc Health, 2000. 27(2): p. 130-5.
3. Murray, C.J.L. and A.D. Lopez, The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Global Burden of Disease and injury series. 1996, Boston: The Harvard School of Public Health.
4. World Health Organization, The world health report: 2000: health systems; improving performance. 2000, WHO: Geneva.
5. Mathers, C.D., E.T. Vos, C.E. Stevenson, and S.J. Begg, The burden of disease and injury in Australia. Bull World Health Organ, 2001. 79: p. 1076-1084.
6. Murray, C.J.L. and A.D. Lopez, Mortality by cause for eight regions of the world: Global Burden of Disease Study. The Lancet, 1997. 349: p. 1269-1276.
7. Polinder, S., W.J. Meerding, M.E. van Baar, H. Toet, et al., Cost estimation of injury related hospital admissions in ten European countries. Journal of Trauma, 2005. 59(6): p. 1283-1291.
8. Polinder, S., W.J. Meerding, H. Toet, M.E. van Baar, et al., A surveillance based assessment of medical costs of injury in Europe: phase 2. 2004, ErasmusMC and Consumer Safety Institute: http:/www.euroipn.org/grd/attachments/80/final%20report.pdf.
9. Lyons, R.A., S. Polinder, C.F. Larsen, S. Mulder, et al., Methodological issues in comparing injury incidence across countries. International Journal of Injury control and Safety Promotion, 2006. in press.

10. Murray, C.J., Quantifying the burden of disease: the technical basis for disability-adjusted life years. Bull World Health Organ, 1994. 72(3): p. 429-45.
11. World Health Organization, International Classification of Diseases; 9th edition. 1997, WHO: Geneva.
12. Recommended framework for presenting injury mortality data. MMWR Recomm Rep, 1997. 46(RR-14): p. 1-30.
13. WHO, World Health Organization mortality database. Available from: http://www3.who.int/whosis/menu.cfm?path=whosis,mort&language=english.
14. Mathers, C., T. Vos, and C. Stevenson, The burden of disease and injury in Australia, AIHW, Editor. 1999, AIHW: Canberra.
15. Waller, J.A., J.M. Skelly, and J.H. Davis, Emergency department care and hospitalization as predictors of disability. J Trauma, 1995. 39: p. 632-4.
16. Polinder, S., W.J. Meerding, H. Toet, S. Mulder, et al., Prevalence and prognostic factors of disability after childhood injury. Pediatrics, 2005. 116: p. 810-817.
17. Mackenzie, E.J., J.H. Siegel, S. Shapiro, M. Moody, et al., Functional recovery and medical costs of trauma: an analysis by type and severity of injury. J Trauma, 1988. 28: p. 281-297.
18. Essink-Bot, M.L. and G.J. Bonsel, How to derive disability weights, in Summary measures of population health: concepts, ethics, measurement and applications, C.J.M. Murray and J.A. Salomon, Editors. 2002, World Health Organization: Geneva.
19. Essink-Bot, M.L., J. Pereira, J. Packer, M. Scharzinger, et al., Cross-national comparability of burden of disease estimates: the European Disability Weights Project. Bull World Health Organ, 2002. 80: p. 644-652.
20. Van Beeck, E.F., C.F. Larsen, R.A. Lyons, W.J. Meerding, et al., Guidelines for the conduction of follow-up sutdies measuring injury-related disability. J Trauma, 2006. accepted for publication.
21. Krug, E.G., G.K. Sharma, and R. Lozano, The global burden of injuries. Am J Public Health, 2000. 90(4): p. 523-526.

Appendix 8.A Overview of disability weights and duration of health state for injuries in the GBD[a]

Injury groups	GBD weight	Duration of disability (years)
1. Concussion	[b]	[b]
2. Other skull-brain injury	ST[c] 0.359–0.431 LL[d] 0.350[e]	0.107 LL15%
3. Open wound head	0.108	0.024
4. Eye injury	0.300	LL
5. Fracture facial bones	0.233	0.118
6. Open wound face	0.108	0.024
7. Vertebral column fractures / dislocations / sprain / strain	0.266	0.140
8. Whiplash, neck sprain, distortion of cervical spine	[b]	[b]
9. Spinal cord injury	0.725	LL
10. Internal organ injury	0.208	0.042
11. Fracture rib / sternum	0.199	0.115
12. Fracture of clavicle / scapula	0.153–0.137	0.112
13. Fracture of upper arm	0.153–0.137	0.112
14. Fracture of elbow / forearm	0.153–0.137	0.112
15. Fracture of wrist (including carpal bones)	0.100	0.112
16. Fracture of hand / fingers	0.100	0.070
17. Dislocation / sprain / strain shoulder / elbow	0.074	0.035
18. Dislocation / sprain / strain wrist / hand / fingers	0.064	0.035
19. Injury of nerves arm/hand	0.064	LL
20. Amputation upper extremity	0.102–0.165	LL
21. Fracture of pelvis	0.247	0.126
22. Fracture of hip	ST 0.372 LL 0.272	0.139 LL5%[e]
23. Fracture of femur shaft	ST 0.372 LL 0.272	0.139 LL5%[e]
24. Fracture of knee / lower leg	0.196	0.090
25. Fracture of ankle	0.196	0.096
26. Fracture of foot	0.077	0.073
27. Dislocation / sprain / strain of knee	0.064	0.035
28. Dislocation / sprain / strain of ankle/foot	0.064	0.035
29. Dislocation / sprain / strain of hip	0.074	0.035
30. Injury of nerves leg/foot	0.064	LL
31. Amputation lower extremity	0.300	LL
32. Superficial injury (including contusions)	[b]	[b]
33. Open wounds	0.108	0.024

[a] GBD = Global burden of disease study[3]. [b] GBD weights and duration of disability are not known for concussion, whiplash, and superficial injury. [c] ST = Short-term. [d] LL = Lifelong. [e] For other skull–brain injury (15%), fracture hip (5%), and fracture femur shaft (5%) a proportion of patients has lifelong sequelae. The other patients have short-term disability.

Appendix 8.B All cause crude mortality rates (crude and age-standardised) by country by age

Country	Age	1999		Average of the last 3 available	
		Crude MR	Age SMR	Crude MR	Age SMR
Austria	0-14	7.6	7.9	5.9	6.1
Denmark	0-14	6.6	6.7	5.8	5.8
Ireland	0-14	8.2	8.4	7.4	7.5
Netherlands	0-14	5.9	5.9	5.1	5.2
Norway	0-14	6.4	6.5	5.6	5.7
United Kingdom	0-14	4.6	4.8	3.9	4.0
Austria	15-24	49.6	49.6	44.8	44.9
Denmark	15-24	33.9	33.4	32.2	31.9
Ireland	15-24	42.4	42.7	45.3	45.5
Netherlands	15-24	23.7	23.6	23.7	23.7
Norway	15-24	43.1	43.0	40.2	40.1
United Kingdom	15-24	28.2	28.3	26.4	26.5
Austria	25-44	42.4	42.5	40.8	40.8
Denmark	25-44	45.9	46.1	43.2	43.3
Ireland	25-44	38.4	38.1	40.7	40.5
Netherlands	25-44	23.9	23.9	23.6	23.6
Norway	25-44	32.8	32.7	33.7	33.8
United Kingdom	25-44	31.2	31.2	30.2	30.2
Austria	45-64	55.2	55.3	55.1	55.0
Denmark	45-64	51.1	51.3	50.4	50.4
Ireland	45-64	41.4	41.7	41.5	41.6
Netherlands	45-64	27.0	27.0	27.5	27.5
Norway	45-64	37.9	38.0	38.3	38.4
United Kingdom	45-64	27.8	27.8	27.0	27.0
Austria	65+	129.7	118.1	133.1	121.5
Denmark	65+	221.5	182.6	225.5	184.4
Ireland	65+	125.2	118.1	112.6	104.9
Netherlands	65+	109.0	97.7	105.3	94.3
Norway	65+	199.7	162.7	186.0	148.6
United Kingdom	65+	82.4	70.4	85.0	71.4

Country	Age	1999		Average of the last 3 available	
		Crude MR	Age SMR	Crude MR	Age SMR
Austria	Total	53.9	47.4	53.3	46.2
Denmark	Total	64.7	52.0	64.0	50.8
Ireland	Total	42.8	41.9	42.4	41.3
Netherlands	Total	32.8	28.8	32.2	28.3
Norway	Total	55.6	44.0	53.1	42.2
United Kingdom	Total	33.0	28.4	32.8	27.7

9

Societal discounting of health effects in cost-effectiveness analyses: the influence of life expectancy

Suzanne Polinder, Willem Jan Meerding, Job van Exel and Werner Brouwer

Pharmacoeconomics. 2005; 23: 791-802.

Abstract

Background Increasing life expectancy and decreasing marginal valuation of additional QALYs over time may serve as a basis for discounting future health effects from a societal perspective. Therefore, we tested the hypothesis that societal time preference for health is related to perceived future life expectancy.

Methods A sample of 223 people from the general population prioritised health care programmes with differential timing of health benefits and costs from a societal perspective. Furthermore, we asked respondents to estimate future life expectancy.

Results The relationship between future life expectancy and time preference for health is ambiguous. We observed that people who expected a higher future life expectancy elicited higher discount rates for effects than those with lower growth expectations for all four time periods (5, 10, 20 and 40 years into the future), but the differences were never significant. On average, providing explicit information on growth in life expectancy did significantly alter discount rates in the expected direction, but on an individual level the results were rather inconsistent. We observed a significantly stronger time preference (i.e. higher discount rates) for health effects than for costs. As commonly observed, discount rates for health and money decreased with time delay, following a hyperbolic function.

Conclusion Our data indicate it is troublesome to elicit societal discount rates empirically, especially rates that are in line with the theoretical arguments on societal discounting. The influence of life expectancy remains ambiguous, but there seems to be at least some positive relationship between growth and discount rates that deserves additional attention.

Introduction

In cost-effectiveness analysis (CEA), discounting costs and health benefits in the future is an issue of considerable debate. However, there is a broad practical consensus to discount both costs and health effects with an equal discount rate of 3-5% [1, 2]. It appears that two theoretical arguments, the consistency argument of Weinstein and Stason [3] and the postponing paradox of Keeler and Cretin [4] are mostly responsible for this approach.
Weinstein and Stason [5] argued that programmes with an equal CE ratio at different points in time should receive equal priority and this can only be achieved by using the same discount rates for costs and effects. The crucial assumption underlying this reasoning is that "life years are valued the same in relation to dollars in the present as in the future". Thus, a "constant steady-state relationship between dollars and health benefits" is assumed and "opportunities for purchasing health benefits for dollars do not change over time". Keeler and Cretin [5] argued that if one does not use the same discount rates for costs and effects, but rather a lower one for effects than for costs, infinite postponing of programmes would be the preferred option. This holds because the CE ratio of a postponed program is always better than the currently executed program, since future costs are devalued more quickly than future effects, making the C/E ratio lower. This can be illustrated by a simple example: we have a program that costs $1000. Costs will be discounted by 5% and effects will not be discounted. The C/E ratio for this year will be $1000 per QALY. After one year the C/E will be $952 per QALY ($1,000/1.05)[1]. Infinite postponing would thus be optimal, since this rule always applies.
Recently, however, the two above-mentioned theoretical arguments [3, 4] have been criticized and many authors have questioned whether the discount rate should be equal for costs and effects [2, 6-10]. Importantly, Van Hout [7] has demonstrated that the consistency argument holds only if one assumes (like Weinstein and Stason [3] do) that a 'constant steady-state relationship between dollars and health benefits' exists. Van Hout argued that this crucially depends on the marginal valuation of dollars and health benefits over time, which depends (amongst other things) on the growth rates for wealth and health (which need not and probably are not equal). Moreover, although the theoretical reasoning of Keeler and Cretin [4] may be correct, the option of infinite postponing of healthcare expenses are not relevant in a world where budgets have to be spent [1, 7]. Both arguments have recently been further criticised by Gravelle and Smith [9].
This debate on appropriate discount procedures may seem quite theoretical; however, it is also very important from a practical perspective since the choice of discount rate used in an economic evaluation can alter the results of a CEA considerably [11]. Importantly, for preventive medicine the discount rate for effects can reduce the net effectiveness of a programme dramatically, since using a 5% discount rate implies that seven QALYs gained 40 years from now are counted as about one QALY gained this year [7]. Without a proper

---

[1] Discounting is calculated as $1/(1+r)^n$, where r is the discount rate and n is the number of years, in this case 1/1+0.05.

justification of such a weighting procedure one may feel that this places too little weight on future QALYs and inappropriately favours curative over preventive programs.
Therefore, it is important to scrutinise the theoretical foundations of current practice in economic evaluations. However, abandoning old standard practices requires that we can replace them with new (and better) practices. In other words, assuming for the moment that there is no necessity for using the same discount rate for costs as for effects, we still face the difficult task of finding a new set of discount rules and appropriate rates for costs and effects. This can only be achieved with both theoretical and empirical research.
In terms of finding a new theoretical basis on which to base discount rates for costs and effects, Van Hout [7] argued that the discount rate for health should be based on the expected growth in life expectancy and the diminishing marginal utility related to additional life time. Similarly, Gravelle and Smith [9] have recently argued that if the value of health is assumed to grow over time, the discount rate for effects should be lower than that for costs. Brouwer et al [11] argued that taking a societal perspective in economic evaluations, as normally advocated, requires a more objective weighting of future QALYs. A fair societal discounting procedure would require that the valuation of future health effects should only depend on the timing of effects when obvious differences between people at different points in time are present or can be rightfully expected. Increasing life expectancy and therefore decreasing marginal valuation of additional QALYs over time may serve as an objective measure for relevant differences between people over time [7, 11, 12]. Moreover, from a societal perspective the decision-maker may (need to) overrule the individual 'time horizon', also taking into consideration the position of future generations, and base discounting solely on real differences between people over time that change the relative valuation of health effects (at the point of occurrence). The current method of discounting, however, is not based on the differences in the valuation of effects over time.
Changes in life-expectancy over time can be used in an efficiency and an equity argument to discount future health effects [11]. In terms of efficiency, diminishing marginal utility from additional life-years is a reason to trade off future health gains against present health gains. One might also consider it to be more equitable to attach more weight to a QALY gained in someone with a low life-expectancy than in someone with a high life-expectancy, which seems an intergenerational application of the fair innings argument made by Williams [13].
The arguments put forward to base discount rates on growth rates of health and wealth have mainly been prescriptive to data. It needs noting that the model presented by Gravelle and Smith [9] seems the best attempt to bridge the gap between prescriptive and descriptive arguments, in that their (prescriptive) model can be made directly operational by using empirical estimations for the discount rates of both costs and health effects.
Fully descriptive research, directly investigating the association between growth in life expectancy and the valuation of future health in the general public, to the best of our knowledge, is lacking. A brief assessment by Brouwer and Van Exel [10] found mixed evidence that expectations on growth in life expectancy are related to the discount rates

for health. It would, however, be interesting to see whether people in the general public relate the valuation of future health effects to the growth in (quality adjusted) life expectancy and to see whether there is some positive support for the normative arguments made in the literature, to date. Although one may argue that it is questionable whether the general public can or should be asked to specify societal discount rates (since they may inevitably place more weight on the present than is desirable from a truly societal perspective), they are an important valuation source in health care [10].
The objective of this chapter is to test two hypotheses: 1) the societal discount rate differs for health and money, by time delay; and 2) respondents with a higher expected overall life expectancy have a higher time preference for health effects (i.e. a stronger preference for immediate versus future health gains). In doing so, we asked people to make 'societal judgements' not private judgements, assuming they are health care decision makers. It needs noting that whether the derived societal discount rates for costs and effects are different or similar has been investigated before and, contrary to the theoretical arguments in the literature, the discount rate for costs is generally lower than that for effects, inversely related to outcome magnitude and delay in realising beneficial effects [14, 15].

Materials and methods

Questionnaire

We developed an interactive computer-based questionnaire that performed skip-patterned questions. The questionnaire started with a short introduction in which the respondent was asked to imagine he or she was a decision maker confronted with societal choices between competing health care programs that differed with respect to the timing of health effects or costs. The questions were framed from a societal perspective. The societal perspective is normally considered the proper perspective from which to conduct a CEA, because it facilitates a fair representation of all costs and health effects [1]. The questionnaire consisted of four parts. The approached subjects were a sample of the general population, recruited from a database of an internet-survey agency (n = 400).

Part I: Patient characteristics

In *Part I: Patient characteristics,* the following patient characteristics were obtained: age, gender, education, income, and respondents' health state using the EuroQol Five-Dimension Questionnaire (EQ-5D) [16].

Part II: Time preferences for health effects and costs

Part II: time preferences for health effects and costs consisted of a number of discrete choices about health and money. The questions were purposely concerned with health gains and money losses, since decision makers most often have to choose among interventions that cost money and generate health benefits.

For the health effects, respondents were asked to make trade-offs between a hypothetical scenario of future and present health gains. The questions were based on the phrasing used by Olsen [17, 18] and Lazaro et al. [14], who combined open-ended and closed-ended methods for the research questions. Each discrete choice started with a choice between programmes generating 1000 healthy life years in 1 year or 1000 healthy life years in the future. If the respondent preferred either of the two options, he/she was asked to specify the amount of current or future health gains that would make the programs equally good. If the respondent was indifferent, the trade-off question was not presented. Time horizons of future events used were 5, 10, 20 and 40 years.

The questions for measuring time preferences for costs had an identical format as for health benefits. The discrete choices started with the ordinal choice between two programs. Both programs realised hundred healthy life years in 1 year. For one program the costs are €1000 now and for the other program the same amount of money has to be paid in the future. An example of the question related to health effects and costs is also included in Appendix 9.A.

Part III: Influence of life expectancy on time preferences for health effects

Part III: Influence of life expectancy on time preferences for health effects consisted of two questions. Firstly, respondents were asked to estimate population life expectancy 5, 10, 20 and 40 years from now. The current life expectancy was given (78 years). Furthermore, respondents were confronted with the same ordinal choice with respect to the time preference of health as for part II, using a time delay of 40 years. In this question however life expectancy after 40 years was given and set at 82 years, to 'force' respondents to consider life expectancy.

Part IV: Propositions

In *Part IV: Propositions* respondents were asked to assess five propositions on the distribution of health across generations on a five-point scale from completely agree to completely disagree. This was done to analyse whether answers were consistent with the discrete choices for health and money and to establish the motivations of respondents to exhibit certain patterns of time preference.

Data analysis

Statistical Package for the Social Sciences (SPSS) version 10 was used to analyse the data. The first part of the data analysis considered the possible existence of inconsistent responses. A response was defined as inconsistent when people first preferred 1000 healthy life years gained now above 1000 healthy life years gained in the future, and subsequently the future program had to produce *less* health to make both programmes equally good (and vice versa). Also when people first preferred one of the programs, and were then subsequently indifferent between the two, the answer was considered inconsistent. Respondents with > 25% of inconsistent answers were excluded from the analyses. We used logistic regression analysis to test whether giving inconsistent answers was associated with respondent characteristics.

<u>Hypothesis 1: The societal discount rates for health and money differ</u>
We assessed the implied time preference rates for health gains and money losses and whether the rates differed depending on the length of the time horizon over which they were elicited?
Respondents' implied time preference rates were estimated with the following calculation:

$$R = (X/1000)^{1/t} - 1$$

where X represents the future amount (health or money) chosen by the respondent for the choice between an immediate and delayed programme to be indifferent and t (5, 10, 20 and 40 years) is the time interval. The mean implied societal discount rates of health and money were compared for each period of delay, and the statistical significance was determined with the Wilcoxon Signed Ranks Test.

<u>Hypothesis 2: Respondents with a higher expected overall life expectancy have a higher time preference for health effects</u>
Respondents' implied growth rate for life expectancy was calculated as follows:

$$Gr = (X/78)^{1/t} - 1$$

where X represents the life expectancy given by the respondent at time t (5, 10, 20 and 40 years) in the future. A multivariate Spearman rank correlation test was used to determine a possible association between growth in life expectancy and the societal time preference with respect to health for each point in time. We also tested with a t-test whether, for each period of delay, the 50% of respondents with the highest estimates of life expectancy had higher discount rates than the remaining 50% of respondents.

Furthermore, we investigated whether explicitly mentioning life expectancy in a discrete choice question (part III) influenced the time preference for health. In the questionnaire, respondents were confronted with two almost identical ordinal choices with respect to the time preference of health using a time delay of 40 years. In one of the questions however life expectancy after 40 years was given and set at 82 years. The Wilcoxon signed ranks test was used to determine whether time preferences differed significantly between both questions. We also analysed whether respondents with a lower estimate of life expectancy than 82 years adjusted their time preference upwards in the discrete choice with explicit life expectancy, and vice versa.

In the last part of our analysis, a 2-tailed Pearson Correlation Test was used to assess the correlation between the answers to the propositions (part IV) and the discrete choices.

Results

A total of 223 subjects completed the questionnaire, yielding an initial response of 56%. The distribution of age and education was representative for the Dutch population [19]. In total 162 persons gave consistent answers on health choices and 113 persons on cost choices. 94 respondents gave consistent answers for both costs and health, 58 for health only, 19 for costs only, and 42 subjects gave neither consistent answers for health or costs. People with a higher education (post-high school) (p=0.076) and men (p=0.006) gave more consistent answers than those with a low (no high school) or middle education (high school graduate) and females, respectively. In table 9.1, the respondent characteristics are shown for the population with and without consistent answers.

Table 9.1 Respondent characteristics of the total population and of the consistent responders with respect to health and monetary choices

Respondent characteristics	**Total population** n=223 (%)	**Consistent responders for the health choices** n=162 (%)	**Consistent responders for the monetary choices** n=113 (%)
Sex			
Men	127 (57)	101 (62)	65 (58)
Women	96 (43)	61 (38)	48 (42)
Age			
15-30	74 (33)	55 (34)	40 (35)
31-50	87 (39)	63 (39)	44 (39)
51-70	58 (26)	41 (25)	26 (23)
>=70	4 (2)	3 (2)	3 (3)
Education			
High	73 (32)	56 (35)	47 (42)
Middle	113 (51)	87 (53)	54 (47)
Low	37 (17)	19 (12)	12 (11)
Health (visual analogue scale)			
0-50	22 (10)	11 (7)	10 (9)
51-70	27 (12)	24 (15)	17 (15)
71-85	62 (28)	50 (31)	34 (30)
86-100	112 (50)	77 (47)	52 (46)

Does the societal discount rate differ for health and money?

Table 9.2 shows that more respondents have a positive time preference for health than for money. When the time horizon increases, the number of people with a positive time preference for health (i.e. preference for health gains now versus later) increases. Only a very low percentage of respondents did not exhibit any time preference for health or money. Table 9.2 indicates that almost 40% of respondents have a negative time preference for costs, meaning that they would prefer to incur costs now rather than later. Furthermore, not all respondents provided answers consistent with a particular preference. Eighty three percent of the population had consistent negative or positive time preferences for health and 80% for costs.

Some respondents gave extremely high values for the number of future years needed to offset immediate health gains; this strongly influences the mean discount rate. For the questions about the time preferences for costs, no extreme values were found. As argued by Olsen [17], extreme values for health effects may indicate a misunderstanding of the task at hand and thus inappropriately influence mean discount rates. However, they may represent a genuine preference, albeit extreme, for present versus future gains in health effects. In order to reduce the influence of these extreme values, we replaced answers over 10.000, 20.000, 30.000 and 50.000 healthy life years gained in 5, 10, 20 and 40 years, respectively, by these maximum values, as performed by Olsen [18]. This means that the trade off of an individual who indicates for example to be indifferent between 50.000 healthy life years gained in 10 years and 1000 years now, was reduced to 20.000 healthy life years gained in 10 years or a 1000 years now [17]. No extreme values were found for the 5-year time horizon, but 12, 16 and 20 extreme values were found for the 10-, 20- and 40-year time horizons, respectively.

Furthermore, it should be noted that a group of respondents (49 of 162 persons) consistently used a 'decision heuristic' in answering questions on equality of 1000 healthy life years now and a certain amount of health effects in 5, 10, 20 and 40 years.

Table 9.2 Percentage of the respondents with positive, negative, and no time preference for costs and health effects

Period of delay (years)	Period of delay (years)			
	5	**10**	**20**	**40**
Health effects (n=162)				
Positive time preference	85	93	93	93
No time preference	9	2	2	2
Negative time preference	6	5	5	5
Costs (n=113)				
Positive time preference	56	60	58	55
No time preference	5	2	0	4
Negative time preference	39	38	43	41

Table 9.3 Mean, median and 25%-75% percentile societal discount rates (%) for health and money and mean implied life-expectancy and growth rate for life-expectancy (%), by time delay

	Period of delay (years)			
	5	10	20	40
Discount rate for health effects (n=162)				
Mean	26.5	20.9	12.6	7.7
Median	38.0	25.9	16.2	9.7
25% percentile	14.9	17.5	12.2	7.7
75% percentile	37.8	25.9	16.2	9.7
Discount rate for costs (n=113)				
Mean	4.9	4.6	1.9	1.3
Median	5.6	6.7	3.4	2.0
25% percentile	(-) 12.9	(-) 6.7	(-) 6.7	(-) 3.9
75% percentile	27.5	6.8	3.4	2.0
Life expectancy (n = 223)				
Mean (years)	79.9	81.2	82.9	85.6
Growth rate (%)	0.19	0.21	0.17	0.14

They indicated that equality was reached if 5.000 (at 5 years), 10.000 (at 10 years), 20.000 (at 20 years) and 40.000 (at 40 years) healthy life years would be gained in the future compared with 1000 healthy life years now.

Table 9.3 shows the calculated mean and median societal discount rates for health and money. We found significantly higher social discount rates for health effects than for money for each period of delay ($p < 0.001$). Discount rates for both health and money decreased with time delay, following a hyperbolic function [14, 17], which is shown in figure 9.1.

Table 9.4 gives an indication of the sensitivity of the results, comparing the population including and excluding inconsistent answers and also for persons who used 'decision heuristics'. Excluding the inconsistent answers (particularly negative time preferences) leads to higher discount rates for health effects and lower discount rates for costs. The persons who used a 'decision heuristic' while answering the questions, had higher discount rates for health effects (38%, 26%, 16% and 10% respectively for a time delay of 5, 10, 20 and 40 years) compared with the results of the total population. The discount rates for the population excluding inconsistent answers and decision heuristics were lower compared with the outcomes of the population with only inconsistent answers excluded.

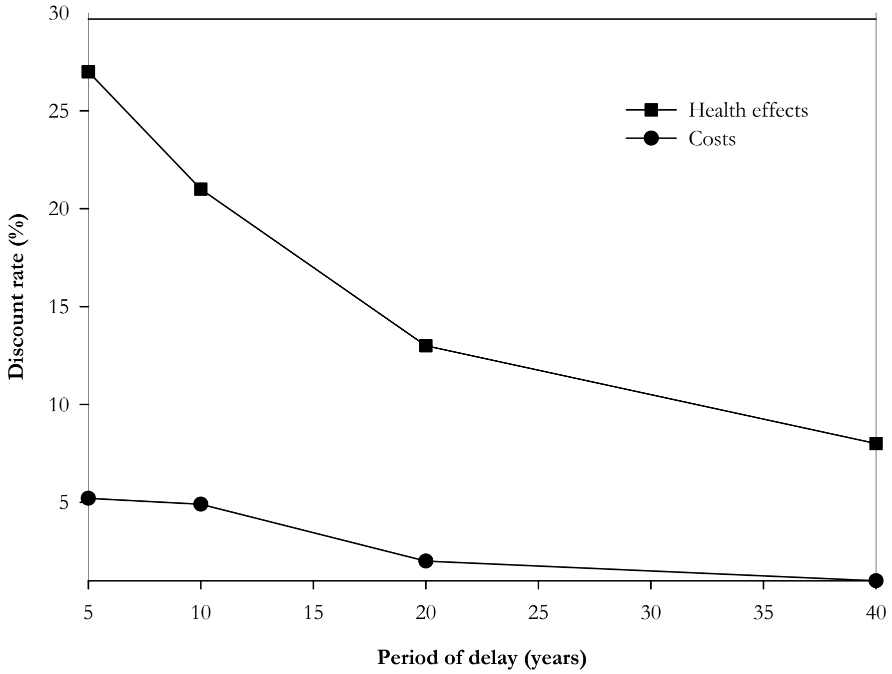


Figure 9.1 Mean implied discount rate (%) for health effects and costs, by time delay

Do respondents with a higher expected life expectancy have a higher time preference for health effects?

Respondents estimated that average life expectancy will increase over the next 40 years and that the estimated growth rate of life expectancy decreases with time (Table 9.3). Positive, but not significant associations were found between respondents' estimates of the growth rate of life expectancy and their calculated discount rate of health, when comparisons were made for each separate period of delay (p= 0.32). Comparing the societal discount rates of health effects for the 50% of respondents with the highest estimates of life expectancy with the remaining 50% of respondents showed that respondents expressing higher estimates of life expectancy estimated higher discount rates for each period of delay: 27.3% versus 25.3% (5 years), 21.5% versus 20.3% (10 years), 12.7% versus 12.4% (20 years) and 7.7% versus 7.6% (40 years). However, these differences were not significant.

Another way of investigating the influence of expectations about future life expectancy on discount rates is to look at changes in discount rates when more explicit information on future life expectancy is given. Since respondents on average estimated an average life expectancy of 85.6 years in 40 years' time (Table 9.3), the given estimate of 82 years implies an expected decrease in life expectancy. Comparing the outcomes of the discrete

Table 9.4: Comparison of mean implied discount rates (%) for health and money for the total population excluding and including inconsistent answers/misinterpretations and persons using a 'decision heuristic' by time delay

	Period of delay (years)			
	5	**10**	**20**	**40**
Total population including inconsistent answers				
Health (n=223)	19.3	14.1	8.9	5.2
Costs (n=223)	7.2	4.6	2.8	2.1
Total population excluding inconsistent answers				
Health (n=162)	26.5	20.9	12.6	7.7
Costs (n=113)	4.9	4.6	1.9	1.3
Total population excluding inconsistent answers and 'decision heurictics'[1]				
Health (n=115)	21.7	18.8	11.1	6.9

[1] They indicated that equality was reached if 5.000 (at t = 5 years), 10.000 (at t = 10 years), 20.000 (at t = 20 years) and 40.000 (at t = 40 years) healthy life years would be gained compared with 1000 healthy life years at t = 0 years.

choices about time preferences for health with and without mentioning life expectancy after 40 years, the discount rate for health was significantly lower ($p < 0.001$) when explicitly mentioning life expectancy in the questionnaire (3.2% versus 7.7%), indicating a stronger preference for future versus present health effects. However, it needs noting that although, on average, the expected decrease was observed, on an individual level matters were more complex. Distinguishing respondents with higher (n = 45) and lower (n = 64) life expectancy than 82 years (after 40 years), both groups showed a lower discount rate when life expectancy was mentioned in the questionnaire (it would have been expected that the first group would lower their discount rate while the second would increase it).

Correlation of discount rate with timing preference for health effects

Finally, the propositions on the distribution of health across generations were analysed. Table 9.5 shows that people preferred present to future health effects (proposition 1, 2 and 4), which implies that people have a positive time preference in a societal context. The discount rate of health had a significant correlation with the propositions in which people indicated present health effects to be more important than future gains; the discount rate increases with the strength of preference for present versus future gains. Proposition 4 also indicated that the respondents accepted the growth rate in health as a measure for relevant differences between people over time. However, the majority of the respondents also agreed with the proposition reflecting the importance of considering future generations (proposition 5), even when this suggested that equal weight should be given to health gains in current and future generations. Paradoxically, this implied that the same respondents now suddenly would favour zero time preference. For proposition 5, no correlation with the discount rate of health effects was observed.

Table 9.5 The time preference of health effects and the Pearson correlation with the discount rate

Propositions	completely agree	agree	neutral	disagree	completely disagree	P-value
1. Gains of healthcare are more important now than over 10 years, since nobody knows how the world looks like right then	23	36	20	15	6	0,112**
2. While we are paying at this moment for the health care, it is a fair judgement that health care gains at this moment are more important than health care gains in the future	13	28	31	22	6	0,173***
3. It is better to give an extra life-year on a person with a life expectancy of 60 years, in stead of somebody with a life expectancy of 80 years	11	20	21	32	16	0,075*
4. It is better to invest in the health care of people who live at this moment, while people probably become older in the future and stay more healthy, because of the increasing medical technology	15	45	24	11	5	0,158***
5. In decision making the health care of future generations should get the same importance as the health care of the present generation	25	44	16	11	4	0.05

Note: The discount rate increases with the strength of preference for present versus future health gains.
Pearson correlation: * $p<0.05$, ** $p< 0.01$, *** $p< 0.001$.

Discussion

In this study we observed a significantly stronger time preference for health benefits than for money. Our first hypothesis can therefore be accepted. Only a few studies have compared, from a societal perspective, the discount rate of health effects with that of money [14, 20-22]. These studies showed comparable discount rates with our study for identical time horizons. Lazaro et al. [14] showed mean discount rates of 25.1% and 8.4% for health and money, respectively, after 4 years, compared with 26.5% and 4.9% after 5 years in our study. This is interesting because the theoretical arguments in the literature are almost exclusively arguing for identical or lower rates for health consequences versus those of money [6, 15]. This emphasises the necessity to find an appropriate discount rate for health effects and to bridge the apparent gap between theoretical arguments and empirical findings in this area. Moreover, it is noteworthy to indicate that in this study discount rates decreased with time delay for health benefits as well as for costs, following a hyperbolic function. This is also in line with previous research, but also indicates a gap between theoretical arguments against hyperbolic discounting (e.g. time inconsistency) and empirical findings.

The framing of the questions could have influenced the relatively high discount rate for health compared with that for money. The questions about health effects were positively formulated (health gains), while the questions about money were negatively formulated (costs). Lower discount rates for losses and higher rates for gains are known in the literature as the sign effect, which is explained by risk aversion. The high implied societal discount rates for health may reflect an obligation to do something for those who need health care now rather than spending resources on programmes which prevent currently healthy people from getting sick in the future [17]. This high percentage (almost 40%) of responders with a negative time preference for costs indicates that they would prefer to incur costs now rather than later. This may indicate that the respondents adhered to a puritanical ethic that it is better to suffer first and enjoy the benefits later. In both cases additional information on the reasoning of respondents seems warranted [15]. However, although the framing of the questions may cause different discount rates between health and costs it must be realized that costs are normally incurred as "losses" while health effects are normally incurred as "gains" when evaluating a healthcare programme.

The second hypothesis of this chapter was to investigate in the general public whether empirically elicited societal discount rates were influenced by expectations about future life expectancy, which in more prescriptive literature on societal discounting has been suggested as a possible rationale for discounting future effects. Our results cannot confirm that there is an empirical relationship between (perceived) growth and discount rates of health.

For all four time periods, the discount rate for health for respondents with a relatively high expected growth rate for life expectancy was higher than that of respondents with a relatively lower expected growth rate for health, but the difference was never significant. A larger sample size might have increased the power of the study, but our results indicated that the relationship between life expectancy and time preference is, at most, weak. However, comparing the 50% of respondents with the highest life expectancy with the remaining 50% of respondents, at least a trend could be identified that respondents with higher life expectancy had higher discount rates for each period of delay than those with lower estimates of life expectancy. Moreover, on average our respondents adapted their time preference in the expected direction when provided with explicit information on future life expectancy.

Given the fact that subjective expectations about life expectancy 40 years into the future were higher (85.6 years) than the life expectancy respondents were forced to consider in the second question of part III of the questionnaire (82 years in 40 years time), respondents adjusted their expectations of the growth rate of life expectancy downwards, as evidenced by their lower discount rate for health (3.2% instead of 7.7%) when forced to accept a lower life expectancy estimate. This may indicate a logical average adjustment of discount rates on the basis of life expectancy. Yet cynical observers might feel that any additional information (be it relevant or irrelevant) may change the results in some direction. Indeed, at a subgroup level it was not the case that explicitly mentioning life expectancy lowered the discount rate of respondents with a higher life expectancy than 82 years and increased the discount rate of those with a lower life expectancy. On the other hand, it is standard practice to look at averages rather than at individual answers in this type of research, since respondents are known to be consistently inconsistent [13, 23] and variation in answers is normally high [14, 24]. The influence of life expectancy (estimated or given) on the societal discount rate for health therefore remains ambiguous, but there seems to be at least some positive relationship between growth and discount rates that deserves additional attention, preferably using larger samples.

Methodological issues

There were some general and methodological difficulties encountered in this study that need noting.

First, the response rate in our sample was 56%. The non-respondents may not have had systematically different views, but may rather simply not have wished to participate in such an 'academic exercise' [17]. However, we could not investigate the non-response further.

Second, some of the respondents gave inconsistent answers, especially lower educated people and women. As mentioned previously in this section, this finding is hardly surprising since respondents are known to be 'consistently inconsistent' in expressing time preferences [23]. This indicates that the general population find it difficult to answer questions about time preferences and poses doubts whether all respondents in our study understood the task. The high percentage of responders who gave inconsistent answers in our study suggests they had great difficulty with the task they were given. This is in concordance with other research [17, 25]. Related to this point, it needs noting that a group of respondents (n=49) consistently used a decision heuristic in answering questions on health effects. These answers were relatively attractive and easy choices, and as it turns out, these values were above the mean answers. They were not excluded from the analysis, as these answers were not inconsistent or 'wrong', but one might claim that such answers were "an easy way out" of a difficult question, and indicate a misinterpretation of the question causing one to question whether "true time preferences" were elicited. The inconsistency of answers should be reported more routinely in papers than is current practice, as this would shed more light on the usefulness and accuracy of current estimates of time preference. In that sense, the difficulties in this study may have been encountered in more studies than have been reported.

Third, it might have been better to use more explicit information on life expectancy, rather than using people's own expectations. Although one might claim that if these presented figures do not match respondents own beliefs this might cause some bias [26], explicitly provided information might help respondents to consider this aspect more consistently. Moreover, it seems informative to further investigate the considerations of the respondents while answering questions concerning time preference using qualitative research, especially given the large individual variation between respondents and inconsistencies.

Fourth, the fact that the questions concerning costs were more frequently answered inconsistently than those pertaining to health effects is somewhat puzzling, as the cost-exercise was not more difficult than that to elicit time preference for health effects. It may be that the questions about health (gains) were posed prior to those about money (losses), and this may have confused some of the respondents.

Fifth, it is well known that different elicitation techniques can yield different results. In this study a discrete choice with an open-ended follow-up question was used, in which the choice was initially between A (1000 life-years now) and B (1000 life-years later), which may have induced some starting point bias. However, from the experience in other valuation fields [27, 28], which have shown that fully open-ended questions are (too) difficult for respondents, we felt this format to be appropriate [18].

Finally, one may fundamentally question whether individuals can take a truly societal perspective when assessing their time preference for costs and health effects, and therefore the gap between descriptive and prescriptive research in this area [14] may never be overcome.

Areas for future research

In terms of future research, our study indicates numerous interesting options. First of all, questions meant to analyse people's views about societal time preference for health or money need to be examined carefully. Our study demonstrated the need for more qualitative work to ensure that people are actually addressing the issue that the investigators intended. Pre-testing or 'talking through answers' with responders can give additional information about what they meant by their answers.

Furthermore, qualitative research is necessary to analyse persons considerations while answering time preference questions, e.g. to test whether people are concerned with equity considerations (given the fact that life-expectancy differs between groups) or real time preference.

Earlier in the discussion, we mentioned that cynical observers might feel that any additional information may change the results in some direction. Therefore, it seems interesting to experiment with the order in which the different sections are presented to the respondents in future research. For example, first asking them about the expected changes in life expectancy before the time preference questions would have encouraged respondents to take this into account. This could have been investigated using a split sample design. Another option is to provide explicit information on life expectancy to respondents.

Conclusions

Our starting point was the agreement with Van Hout's prescriptive argument [7] that life expectancy could well serve as an objective measure for the real change in the societal valuation of health effects over time. We investigated empirically whether in the general public the relationship between (expected) growth in life expectancy and discount rates can be observed. It needs noting that such an empirical study is not a way to validate or falsify the theoretical arguments in favour of discounting on the basis of growth rates, since it is fundamentally questionable whether individual respondents can take a societal perspective. Still, it would be encouraging to also find an empirical relationship between growth rates for life expectancy and discount rates for health. Our empirical results are ambiguous in that sense and the respondents indicated much higher discount rates than normally applied in economic evaluations and preferred higher discount rates for health effects than costs, which is opposite to the theoretical arguments [9].
The challenge for future research is to find ways of improving methodology, generating more convincing data and perhaps further bridging the gap between descriptive and prescriptive research in this important area. More elaborated approaches for establishing appropriate discount rates for costs and effects (the best example of which seems that developed by Gravelle and Smith [9]) should be used to solve the inadequate status quo in this area. In fact, it may well turn out that these approaches are more reliable and feasible than trying to derive societal discount rates from individuals, who may be inevitably biased by their own life expectancy.

References

1. Gold, M.R., J.E. Siegel, L.B. Russel, and M.C. Weinstein, Cost-effectiveness in health and medicine. 1996, New York: Oxford University Press.
2. Drummond, M.F., B. O'Brien, G.L. Stoddard, and T. G.W., Methods for the economic evaluation of health care programmes, 2nd edition. 1997, Oxford: Oxford University Press.
3. Weinstein, M.C. and W.B. Stason, Foundations of cost-effectiveness analysis for health and medical practice. New England Journal of Medicine, 1977. 96: p. 716-71.
4. Keeler, E.B. and S. Cretin, Discounting of life-saving and other nonmonetary effects. Management science, 1983. 29: p. 300-306.
5. Injury surveillance programmes, ethics, and the data protection Act. BMJ, 1999. 319(7206): p. 372-5.
6. Parsonage, M. and H. Neuburger, Discounting and health benefits. Health Econ, 1992. 1: p. 71-76.
7. Van Hout, B.A., Discounting costs and effects differently: a reconsideration. Health Econ, 1998. 7: p. 581-594.
8. Smith, D. and H. Gravelle, The practice of discounting economic evaluation of health care intervention. Int J Technol Assess Health Care, 2001. 17(2): p. 236-43.
9. Gravelle, H. and D. Smith, Discounting for health effects in cost-benefit and cost-effectiveness analysis. Health Economics, 2001. 10: p. 587-599.
10. Brouwer, W.B.F. and N.J. Exel, Discounting in decision making: the consistency argument revisited empirically. Health Policy, 2004. 67(2): p. 187-94.

11. Brouwer, W.B.F., F.F.H. Rutten, and B.A. van Hout, A fair approach to discounting future effects: taking a societal perspective. Journal of Health Serv Res Policy, 2000. 5: p. 114-118.
12. Morris, J. and J.K. Hammitt, Using life expectancy to communicate benefits of health care programs in contingent valuation studies. Med Decis Making, 2001. 21(6): p. 468-78.
13. Williams, A., Intergenerational equity: an exploration of the 'fair innings' argument. Health Economics, 1997. 6: p. 117-132.
14. Lazaro, A., R. Barberan, and E. Rubio, Private and social time preferences for health and money: an empirical estimation. Health Econ, 2001. 10: p. 351-356.
15. Chapman, G.B. and A.S. Elstein, Valuing the future: temporal discounting of health and money. Medical Decision Making, 1995. 15(4): p. 373-86.
16. The EuroQol group, A new facility for the measurement of health-related quality of life. Health Policy, 1999. 16(3): p. 199-208.
17. Olsen, J.A., On what basis should health be discounted? J Health Econ, 1993. 12: p. 39-54.
18. Olsen, J.A., time preferences for health gains: an empirical investigation. health economics, 1993. 2(3): p. 257-265.
19. CBS Key figures. In www.cbs.nl.
20. Cairns, J.A. and M. Van der Pol, Constant and decreasing timing aversion for saving lives. Social Science Medicine, 1997. 45(11): p. 1653-9.
21. Cairns, J.A. and M. Van der Pol, Saving future lives: a comparison of three discounting models. Health Econ, 1997. 6(4): p. 341-50.
22. Chapman, Time preferences for the very long time. Acta Psychol (Amst), 2001. 108: p. 95-116.
23. The Economist, Consistently inconsistent, in The Economist Print Edition. 1999.
24. Cairns, J.A. and M. Van der Pol, Negative and zero time preference for health. Health economics, 1999. 9(2): p. 171-5.
25. Cairns, J.A. and M. Van der Pol, The estimation of marginal time preference in a UK-wide sample. Health technol assess, 2000. 4(1): p. 1-83.
26. Van Nooten, F. and W.B.F. Brouwer, The influence of subjective expectations about length and quality of life on time trade-off answers. Health Economics, 2004. 13: p. 819-823.
27. Van den Berg, B., W.B.F. Brouwer, N.J.A. van Exel, and M.A. Koopmanschap, Valuation of informal care: The contingent valuation method applied in informal caregiving. Health Economics, 2005. 14(2): p. 169-183.
28. Kartman, B., N.O. Stalhammar, and M. Johannesson, Contingent valuation with an open-ended follow-up question: a test of scope effects. Health Economics, 1997. 6(6): p. 637-9.

Appendix 9.A Example of time preference questions

1.1 Question about time preferences for health effects

Assume now that you are a decision maker in health care. You have to choose between competing health care programmes on behalf of society of which the costs are equal. The only difference between the programmes is when healthy life years are gained.

Which of the programs do you prefer?
o program A: saving 1000 healthy life years in one year.
o program B: saving 1000 healthy life years in 5 years.
o A and B are equally good

If you chose A:
How many lives do you think program B would have to save in order for A and B to be considered *equally good*? Answer: ……..healthy live years.

If you chose B:
How many lives do you think program A would have to save in order for A and B to be considered *equally good*? Answer: ……..healthy life years.

1.2 Question about time preferences for costs

Assume now that you are a decision maker in health care. You have to choose between competing health care programmes on behalf of society. Both programmes save 100 healthy life years in one year.

Which of the programs do you prefer?
o program A: the costs are €1000, which should be paid in one year
o program B: the costs are €1000, which should be paid after 5 years.
o A and B are equally good

If you chose B:
How much do you at the most want to pay for program A, in order for A and B to be considered *equally good*? Answer: € … .

If you chose A:
How much do you at the most want to pay for program B in 5 years, in order for A and B to be considered *equally good*? Answer: € … .

10

General discussion

Comparability of injury incidence data

Main findings

Research question 1: How can the international comparability of injury incidence data be improved?
Answer: International standardisation of the design and analyses of hospital data, and the use of injury indicators improve the comparability of injury incidence data.

This thesis described the methodological challenges and devised solutions to compare injury incidence across countries. International standardisation as we performed in the EUROCOST project is a necessary condition for the comparability of injury incidence data. We showed that the use of a clear operational definition of 'injury', a clear description of inclusion and exclusion criteria, and of the classification systems used is essential. Implementation of this data standardisation in ten European countries revealed that data systems become more comparable across countries, but that there remains international variation in injury incidence. Injury indicators can help to adjust for differences in severity distribution in order to detect real rather than artificial variation in injury frequency between countries. We showed that indicators based on outcome criteria (disability weights) and anatomical criteria (long bone fractures) improved the comparability of clinical injury incidence data (HDR). Furthermore, we have defined an ED based injury indicator that only includes injuries with 'need' for ED visit, and improves the international comparability of injury incidence data (ED and HDR). This indicator includes a subgroup of selected radiologically verified fractures (SRVFs). The choice of the indicator depends on the specific research or policy question addressed.

How valid are the results?

Data standardisation and the application of injury indicators in ten European countries resulted in more valid injury incidence comparisons. The question remains, however, whether the remaining differences in injury incidence are real or due to differences in registration practice and health care policy between countries. Our data standardisation is a first step to improve the comparability of injury incidence data. However, there are still some important methodological issues that need to be further improved. We classified injuries based on diagnostic information, as available in national hospital-based data systems. It was not possible to operationalize injury severity with the Abbreviated Injury Scale (AIS). As a result, we might have insufficiently discriminated among severe and less severe injuries, especially among patients with very severe injuries (e.g. patients admitted to hospital due to skull-brain injuries). Also, polytrauma patients could not be distinguished. The availability of adequate data on injury severity would make the model more supportive for policy making, especially with regard to severe injuries. Furthermore, inadequate extrapolation of ED data towards national level is still a possible source of variation in injury incidence data.

It is questionable whether for the total heterogeneous injury population reliable trend analyses or international comparisons can be made. Particularly incidence rates of minor injuries are influenced by differences in registration practice, health systems and health care policy. It might be better to focus on the more severe injuries to overcome these methodological issues. Injury indicators, as developed and tested in this thesis, can be applied to routinely collected data as a severity threshold for the case definition. For international comparisons of injury incidence, indicators based on anatomical criteria or disability weights are sensible indicators to use, in the absence of a direct measure of anatomical severity

Recommendations and future research

A naive use of hospital-based data systems for international comparisons and national trend analyses bears the risk of measuring artificial instead of real differences in injury incidence between countries, patient groups, or time periods. The recommended methodological considerations and developments should be further refined and tested to provide tools for those who need to compare injury incidence data.

To minimise incomparability resulting from misclassifications, differences in injury classification, and/or a very low incidence, we advise to use injury groups on clustered level (e.g. injuries vertebral column and spine, skull-brain injury, fractures of hip/femur shaft, upper extremity fractures). We recommend using more detailed injury groups when data validity is doubted, or when specific injury groups are analysed. If necessary, results of specific injury groups can subsequently be analysed in more detail.

For the further validation of specific injury indicators we recommend to use larger samples of injury patients. This validation should include more countries and regions within countries, to increase the power and validity of the outcomes.

An indicator should be developed for moderately severe injuries. This is not likely to be possible using hospital inpatient data alone, since many moderately severe injuries are treated in ED departments or other outpatient settings without need for hospital admission. An indicator for moderately severe injuries could be based on an anatomical measure for severity. However, this information is at this moment not available in most ED systems. We recommend to routinely collect information on injury severity (e.g. AIS) in ED based surveillance systems. An alternative could be to derive cut off points for severity of ED patients from panel sessions with patient profiles.

COI and BOD studies make extensive use of routinely collected surveillance data that are not primarily collected for scientific research. As a consequence the data owners have no incentive to collect data for scientific purposes. It could be a big step forward if these data sources aim for constancy in definitions, quality and coverage of incidence data. We recommend that governments take up responsibility to realize this.

Cost of injury

Main findings

Research question 2: What are the medical costs of injury in European countries and can international variation be explained?
Answer: the average medical costs of hospitalised injury patients were €23 per capita. Large international differences in health care costs of injury were observed between European countries, due to differences in injury incidence, health care use, and cost prices.

Within the framework of the EUROCOST project, a uniform method to calculate medical costs of injury was developed and applied in 10 European countries. The mean medical costs were €23 per capita for hospitalised injury patients. The pattern of costs per capita by age, sex, injury type and external cause is broadly similar in all countries. Elderly aged 65 and over, especially women, consume a disproportionate share of hospital resources (on average 36%), mainly caused by hip fractures and fractures knee/lower leg. Young children and male adolescents are also high-cost groups. Home and leisure, sport, and occupational injuries combined make a major contribution (86%) of the total hospital costs of injury in Europe. Large international differences in medical costs of injury were observed between European countries. Major constituents of cost differences are incidence, health system and trauma policy characteristics, and price level differences. At the upper end of the spectrum of international differences, Austria has a high clinical incidence and cost per capita for all injury groups, in particular compared to Spain and the Netherlands at the lower end. The use of the SRVF indicator resulted in a remaining high cross-national variation in injury incidence and medical costs, particularly in children and elderly.

How valid are the results?

Medical costs of injury quantify the combined effects of the incidence and severity (in terms of health care consumption) of injury. This is particularly useful for studies that compare high frequency minor injuries and low frequency severe injuries. Although in many cases health care consumption is strongly related to a patient's health status, international differences in health care consumption do not automatically reflect health care needs, but may be biased by health care systems and policy. Medical costs should therefore be interpreted with caution when used as an indicator for the relative importance of specific injuries.
A major strength of our study is that it presents estimates of hospital costs of injuries based on one uniform method. Due to several harmonization procedures, meaningful

international comparisons between countries and pooling of country-specific data of injury incidence and costs can be made.

The study provides broad insights into cost distributions rather than precise cost estimates. An important limitation of our data is the unavailability of Abbreviated Injury Scale (AIS) scores. Therefore, polytrauma patients (seriously injured patients, usually with multiple injuries) could not be distinguished. The mean costs per polytrauma patient have recently been estimated at €32,166 [1], which far outnumbers the mean costs per patient found in our study. Other information relating severity (e.g. ICU admission) of injury was also not available in the data systems.

In our study we focussed on hospital costs, since no reliable data on other health care consumption was available. Further development of the model should include long term consumption of outpatient care, rehabilitation and/or nursing home treatment. This is particularly relevant for injuries with long-term health care need, such as spinal cord and skull-brain injury [2]. Earlier studies show that hospital care comprises on average 69% of total health care costs in the Netherlands [2], 73% in the United States [3] and 71% in Australia [4].

Generally, we had to use indicators of health care consumption that have a strong but imperfect relationship with real resource use. For instance, we were unable to distinguish between high and low intensity hospital days, thereby underestimating costs of diagnoses that account for a relatively large share of intensive care.

Recommendations and future research

All in all, the issues in managing trauma patients are similar in Europe. As healthcare improves, our populations are increasing in age and with additional comorbidities and decreased physiologic reserve, the elderly are requiring increased intensity and utilization of our health care resources. Injuries among older people should be a priority area in public health policy in all European countries. Additional work should focus on societal cost benefit analyses of interventions targeting elderly, quality of life following trauma and the injury prevention needs (e.g. prevention of falls) of the elderly.

Application of our model has so far been limited to 10 European countries. Countries without nationwide data systems on hospital admissions due to injury (e.g. Germany) did not participate in the project. Expansion of the cost model to other European countries could further enhance its value.

The future development of the cost model concerns the inclusion of more cost items (e.g. costs of outpatient primary care, rehabilitation and nursing home treatment, patient costs, productivity loss) to make priority setting possible, based on total expenses.

Moreover, it would be worthwhile to do cost analyses for specific injury groups (e.g. lower extremity fractures, skull-brain injury, spinal cord injuries) in more detail and disentangle the effect of differences in treatment and operation strategies and differences in the way trauma care is delivered (including the specialties involved, such as trauma surgeons, orthopaedic surgeons and neurosurgeons). Therefore, research in this area

should be encouraged, with the help of trauma centre databases. Trauma centre databases should be centralized on national level and internationally standardized.
As with generic COI studies, the (international) comparability of cost of injury studies could be enhanced by the development of guidelines for conducting and reporting cost of injury studies.

Health impact of injury

Main findings

Research question 3: What is the health impact of injury in terms of functioning and burden of disease, and can international variation be explained?
Answer: Health status of non-hospitalized injury patients (750,000 adults per year in the Netherlands) was equal to the general population's health 5 months after injury. Injury patients with a long hospital stay (> 3 days; 31,000 adults per year) still reflected a significant degree of functional limitations two years after injury. Most injured children showed a quick and full recovery, but a subgroup (12,000 children per year) has residual disabilities in the long term.
There exist marked differences in the burden of injury between European countries, which were the result of a high variation in both premature mortality and disability, but could not be further explained.

Health status of non-hospitalized patients aged 15 years and older was comparable to the general population's health 5 months after injury (EuroQol summary score: 0.87). Health status of patients admitted for 3 days or less improved until 9 months (0.82), but decreased thereafter (0.75 after 24 months). For those admitted more than 3 days health status improved until 24 months (0.48 toward 0.67), but remained below population norms. For hospitalized patients, age and sex (female), type of injury (hip fractures, spinal cord injury, and fractures knee/lower leg) and co-morbidity were significant independent predictors of poor functioning in the long-term. For instance, patients with two or more comorbidities have 9 months post injury an EQ-5D score that is 0.20 lower than for patients without comorbidities.
The vast majority of injured children (5-14 years) reported a good health status already within 3-5 months after the injury (0.92-0.96), but a small subgroup of patients (8%) has residual disabilities 9 months after the injury. Female gender and hospitalization were significant and independent predictors for long-term disability. Girls had a 3-fold risk and hospitalised children had a 3 to 5-fold risk for sub-optimal functioning in the long term.
Furthermore, for 7 European countries, we assessed the consequences of injury in terms of burden of disease expressed in disability, premature mortality and disability-adjusted life years (DALY). Austria has the largest burden of disease resulting from injuries (25

DALY/1000 persons), followed by Denmark, Norway and Ireland (17-20 DALY/1000 persons). In the Netherlands, England and Wales the total burden of disease due to injuries was relatively low (12 DALY/1000 persons). These marked differences were both due to a high variation in premature mortality and disability between the countries. Males aged 25-44 years caused one third of the total injury burden in these seven European countries, mainly due to traffic and intentional injury. Spinal cord injury and skull brain injury contributed most to the burden of disability, mainly due to permanent disability. At country level, specific combinations of external causes and types of injury deserve special attention.

How valid are the results?

Health impact of injury in terms of functioning

A limitation of the Dutch follow-up study was the low response rate (37% for the first questionnaire), which was largely due to the use of postal questionnaires whereas we were limited in the use of response increasing incentives. We had much background information about the non-respondents, and adjusted the data for non-response bias after an extensive analysis in which the impact of patient and injury related factors were investigated. Despite the low response rate of the first questionnaire this study has yielded convincing results. An earlier performed follow-up study on functional outcome of hospitalized injury patients with the same study design [5] resulted in comparable outcomes.

The generic EuroQol instrument appeared to be a feasible and valid instrument for the measurement of functioning and disability in injury patients of five years and older. The instrument discriminated well among our heterogeneous injuries. For instance, the instrument showed a strong discriminative power between hospitalized and non-hospitalized patients, and between specific types of injury, and was sensitive for recovery patterns in time (responsiveness to change). For specific injuries the EuroQol instrument does not measure all important health domains. For instance, the EuroQol summary measure does not include memory patterns and/or ability to concentrate, which can partly explain the relatively good functional outcome of skull-brain injury patients. An item was added on cognitive ability. Furthermore, information on specific health domains (e.g. hand-arm movement) can be collected with other instruments like the Health Utilities Index (HUI). These measurements will most likely result in lower functional outcomes for upper extremity fractures than measured with the EuroQol.

For a large group of non-hospitalized patients, the 2½-month time interval of the first questionnaire appeared to be too long for measuring the impact of the injury on health status (57% had returned to normal health). Because these injuries can be temporarily quite disabling, follow-up of these minor injuries should take place a few weeks after injury. Generally, non-hospitalized injury patients reported a relatively good health after 5 months (even better than the health of the general Dutch population) [6], but a decrease in the second year after injury. A similar pattern was found for patients with a short hospital stay. Due to a temporary worse health state at the time after the injury, persons with minor injuries might overestimate their 9-month health state, since their frame of reference has changed (response shift) [7]. The 2-year outcomes might be a shift (reduction) to the mean health state of the general population, since persons have no longer their poor health state immediately following their injury as reference. But because a definite interpretation cannot be given, the 9- and 24-month measurements need to be interpreted with caution.

Health impact of injury in terms of burden of disease

There are several issues, which require further development in order to improve the assessment of (international variation) in the burden of injury. Injury mortality data are considered to be rather stable, except for elderly (65+), in whom mortality rates for unclassified (unknown) injuries vary widely (from 4.9/100,000 for Ireland to 42.0/100,000 for Netherlands) and co-morbidity is an issue of concern. Therefore, the estimated differences in YLL and DALYs in elderly should be interpreted with caution.

The calculation of the short term YLD also has some limitations. The share in total burden is low (for most countries less than 2%), which is partly influenced by the data and also by the DALY methodology. For some frequently occurring minor injuries (concussion, superficial injury), no disability weights were estimated by the GBD study, and consequently no disability could be calculated. Not for all countries incidence data of non-admitted ED patients was available for traffic and intentional injuries, which resulted in sub-optimal international comparisons of short term YLD. However, the influence will probably be modest, since the majority of the injuries of non-admitted ED patients are caused by home and leisure injuries (75%) [8].

An important issue with respect to international variation in long term YLD, is the linkage of the available epidemiological data and disability weights [9]. In our study, all injuries were similarly valued for all countries, irrespective of the severity of the injury (AIS/ISS scores) and differences in health care systems. However, in chapter 4 we concluded that Austria has a high clinical incidence of low severity injuries, indicating a low admission threshold. Therefore, in Austria the burden of injury in terms of YLD could be relatively overestimated.

Recommendations and future research

Studies looking at injury-related disability in comprehensive injury populations are scarce [10]. The studies that could be identified [5, 11-19] all used different inclusion criteria for their study population (e.g. different age ranges, trauma centre patients versus ED-treated patients), different generic measures (EQ5D, SF-36, QWB, FIM, SIP) for health status measurement, and different timings of assessment. All the more this stresses the need for uniform methodologies to generate comparative information among injury groups, over time, and among countries.

First of all, we advise to introduce standard measurement periods (1, 3, 6, 12 and/or 24 months after injury), to increase comparability between studies. To improve the discriminative power between subgroups and to pick up changes over time, a selection of time periods out of these standard measurement periods can be made, based on the particular speed of recovery for hospitalized and non-hospitalized patients. The time intervals used should match the several stages of the recovery process (acute treatment phase, rehabilitation phase, adaptation phase and the stable end situation [10]), which depends on the severity of the injury studied. For instance, we recommend collecting data of non-hospitalized injury patients at 1, 3, and 6 month after injury, to match the quick recovery pattern. To measure the permanent disability of long term hospitalized patients the 24-month measurement can be used as an indication of the stable end situation. In combination with the 3- and 12-month measures the recovery pattern can be described.

Furthermore, we recommend using the EuroQol instrument for the analyses of functioning of large samples of injury patients. Because the EQ-5D measure does not include memory patterns and/or ability to concentrate, an item must be added on cognitive ability. Other instruments should be added to measure relevant health domains not covered by the EQ-5D. For instance, information on hand-arm movement can be collected with the FCI or HUI.

The EuroQol can also be applied in children. Children's self-report may be theoretically preferable because it is consistent with the subjective nature of the EuroQol (made for self completion), and evidence is emerging that children are able to provide accurate and reliable information concerning their health status [20, 21], at least for children aged 12 years and older. For younger children parent proxy report can be used. Research on the feasibility and validity of health status measurements of injured children under age four is highly needed.

In addition to health status, a standard set of personal and injury related variables should be collected that is associated with disability. For instance, our study demonstrated that pre-existing co-morbidity highly influences functional outcome in injury patients. Therefore, co-morbidity data should be collected to enable adjustments for co-morbidity in the analyses of functional outcome after injury.

It would be worthwhile to collect data on pre-injury levels of functioning as well, since it is known from the literature that pre-injury levels of functioning by age and sex may differ from general population norms [10, 22].

Finally, international studies on the frequency and severity of permanent disability of injuries are highly necessary. Research is needed to further explain differences in functional outcome and recovery patterns between injury patients. Thereafter, trauma care should be targeted at early identification and management of the particular needs of high-risk groups of long term disability.

The collection of valid empirical epidemiological data on the functional consequences of diseases and injury, the health state measure used, and the measurement of functioning is a prerequisite to make more valid calculations on the population burden of disease due to

injury. Furthermore, there are several issues, which require further thinking and development in order to improve the validity of the measurement of the burden of disease due to injuries.
Permanent disability dominates the YLD and the DALY outcomes. Co-morbidities can highly influence the recovery process and the presence of permanent disability of injury patients. Therefore, co-morbidities should be taken into account in calculating the burden of injury. However, there is continuous discussion about how to handle co-morbidity in burden of disease studies [23, 24]. There are a number of issues, which need to be addressed, including how to model the effect of co-morbidities on disability weights, how to deal with co-morbidities from common causes?
It is important that empirical disability weights and injury incidence data are consistent. Particularly frequently occurring injuries with mild functional sequelae are sensitive to variation in disability weights [25]. Disability weights for less severe injuries should be (further) refined, to improve the adequacy of short-term YLD calculations. Long-term YLD calculations should be interpreted with caution. For this moment, it might be better to use a cut off point for international DALY calculations, by only including long term YLD and YLL.
Summary measures of population health are primarily based on the available epidemiological data, which makes agenda setting for the collection of these data the most important issue to emerge from burden of injury estimation. More detailed registration of incidence, prevalence, mortality and burden for specific injury groups (e.g. spine/vertebrae, skull brain injury) is necessary.
Based on our current study, we conclude that males in the age of 25-44 years with traffic and intentional injuries are an important spearhead. Future research should also identify the major risk factors contributing to the burden of injury.

Cost of illness, burden of disease and economic evaluation studies

In this paragraph the influence of the discount value choice on BOD and COI studies is described. Furthermore, we will illustrate that analysing costs and burden of injury in a combined perspective has added value, by giving an example of a cost-effectiveness analysis.

The choice of the discount rate

Discounting future costs and health benefits is an issue of considerable debate. This debate concerns the arguments why discounting is applied, the appropriate discount rate, the shape of the discount function, and finding an objective measure for relevant differences between people over time.
Discounting future health and costs is a major issue because it can alter the results of BOD, COI studies and of economic evaluation studies considerably. Using a 5% discount rate implies that seven QALYs (gained) or DALYs (prevented) after 40 years are counted

as about one QALY (gained) or DALY (prevented) this year. Likewise, discounting reduces the importance of the burden of diseases and injury in children relative to elderly, and might therefore result in morally unacceptable allocations between generations. In the field of injury prevention, often focused at young people, the height of the discount rates can reduce the net effectiveness of a programme dramatically. Therefore, a proper justification of the discounting procedure is required. Discounting can be used to make a balance between short and long term costs and health effects, and should therefore only be used when a choice should be made between two or more alternatives at individual or societal level (which for example is the case for a CEA between 2 or more injury prevention policies). For descriptive BOD or COI studies no choices have to be made between interventions in time, which makes discounting not necessary. We therefore recommend to avoid discounting future costs and health effects in descriptive burden of disease and cost of illness studies.

Another issue is to find an appropriate discount rate for costs and health effects. In our empirical research, we observed a significantly stronger time preference (i.e. higher discount rates) for health effects than for costs. A fair societal discounting procedure would require that the valuation of future health effects is related to existing differences between persons or groups on different points in time. Higher life expectancy and therefore lower marginal valuation of additional QALYs over time may serve as an objective measure for relevant differences between people over time. One might consider it to be more equitable to attach more weight to a QALY gained in someone with a low life-expectancy than in someone with a high life-expectancy. Our empirical research indicates that there might be a positive relationship between life expectancy growth rates and discount rates. Additional research on this issue is recommended, preferably using larger samples.

Economic evaluation studies

The research presented in this thesis has shown that the priority areas in international and national health policy will depend on the used criteria, particularly health burden or health care costs. In chapter 4 we concluded that elderly women (65+) consume a disproportionate share of health care costs. Alternatively, chapter 8 demonstrates that males 25-44 years are responsible for a disproportionate share of the assessed burden of injury. This demonstrates that health care costs and the health impact of injury are complementary indicators for national and international health policy. Ideally, costs and burden of injury should be analysed in a combined perspective.

Burden of disease (BOD) and cost of illness (COI) studies provide essential information to identify injuries, risk factors and population groups with the highest need for intervention. BOD and COI studies a) help identify injury areas where research and the design and implementation of (cost-) effective interventions is most needed, b) generate comparative information on population health and health care costs that deserve further exploration, c) help identify important epidemiological and health care data gaps, d) give insight in the relative importance of prevention, curative and caring activities for specific injuries, and e) act as a reference framework to trace the actual impact of interventions on population health and health care expenditure [26]. Because BOD and COI studies provide national estimates in disease burden and costs, they may be an input into and reference framework for economic evaluations of interventions. However, BOD and COI provide no information about the optimal path towards improving population health, which among others depends on the relative cost-effectiveness of interventions. An example is given of an economic evaluation of preventive fall reduction interventions in elderly in the Netherlands.

Example CEA: Cost-effectiveness of fall-reducing interventions in elderly females

Accidental falls are a major cause of injury in the elderly (age > 65), and lead to high medical costs and disability. Major risk factors for falls are previous fall (RR 1.2-3.3), consumption of psychotropic drugs (RR 1.6-28.3), and female sex (RR 1.6-2.1). There is evidence that several interventions for preventing accidental falls in elderly are effective, among which reduction of psychotropic drug consumption and multi-factorial interventions [27]. We investigated the relationship between the medical costs and health effects of fall-reducing interventions with a multi-state life table model. The medical costs with and without the intervention were estimated based on the European cost model (chapter 5). Health care effects were expressed in DALYs (chapter 8), measured with mortality data (YLL) en information about disability (YLD). Functional outcome and incidence of fall injury was estimated with data from a national injury surveillance system and the national hospital discharge database (chapter 6). We simulated two interventions among elderly presenting with a fall on the ED: a multi-factorial intervention with screening on several risk factors followed by targeted interventions, and a geriatric assessment followed by psychotropic drug control. Evidence on effectiveness of interventions was taken from the Cochrane Review [27]. Fall-related costs and disability information were from a burden of injury model. Intervention costs were taken from the literature and from local data sources. The main results are shown in table 10.1.

Psychotropic drug control would cost €13,400 per DALY prevented. A multi-factorial intervention targeted at identified risk factors is likely to be cost saving and reduces falls. We conclude that interventions for the prevention of accidental falls in elderly females may be within acceptable cost-effectiveness ranges. Multi-faceted interventions are likely to be more cost-effective than psychotropic drug control, but their budget impact is higher and more evidence is needed on the effectiveness of individual components. Modelling enables flexible combination of epidemiological data (part I thesis), costs (part II thesis), quality of life (part III thesis), and trial results.

Table 10.1 Results

	Psychotropic drug control	**Multi-factorial intervention**
Health effects		
Incidence (ED visits)	- 148	- 1022
YLD ST / patient prevented (depends on injury type)	-0.25-0.50	-0.25-0.50
Mortality	- 2	- 17
YLD prevented	-13	-114
DALY prevented	-21	-219
Costs (€)		
Number of patients	19 000	21 000
Total intervention costs	1 900 000	3 000 000
Saving medication costs	- 1 000 000	n.a.
Reduction of fall incidence	- 600 000	-7 700 000
Total	300 000	- 4 700 000
Costs / DALY prevented	**€ 13,400**	**< € 0**

Source: Meerding W.J., Polinder S., van der Cammen, T.J.M., Ziere, B., Mulder, S., Toet, H., van Beeck, E.F. Cost-effectiveness of fall-reducing interventions in elderly: a modeling study. *In preparation*

Choices always have to be made about how to allocate scarce resources, both across and within different injury problem areas. Economic evaluations make these choices more explicit. In comparing economic evaluations of different interventions, policy makers must be aware that several factors can influence the results. Population characteristics and environmental factors may predispose people to a particular injury problem [28]. Consequently, the costs, as well as the effectiveness of the intervention will vary across populations, creating differences in economic evaluations. Furthermore, interventions with the lowest cost per unit of health gain are not necessarily always the best choice. Other alternatives may yield larger benefits, but at a slightly higher price. Also, choosing prevention programs to address a problem requires weighting the overall size of the problem.

With injury, a major cause of morbidity and mortality worldwide, policy makers face a major task in seeking to choose the best interventions to implement. Economic evaluations of injury prevention and control programs that are of a high quality offer useful information regarding the efficiency of alternative sources of action. Together with concerns of equity and political feasibility, efficiency considerations help answer questions about how to allocate injury prevention and control resources in such a way as to maximise the returns on investment.

Conclusions and recommendations

Conclusions

- International standardization of hospital-based data systems and the use of injury indicators improve the comparability of injury incidence data between countries.
- Health care costs of injury combine incidence and severity of injuries, and therefore enable rapid (international) comparisons among injuries with different severity levels and health care need.
- The EQ-5D instrument is a feasible and valid instrument for the measurement of functioning and disability in injury patients of all severity levels in the age of five years and older.
- The availability of standardised epidemiological data on the functional consequences of injury is a prerequisite to make valid calculations on the burden of disease due to injury.
- In terms of costs, functional consequences and burden of disease, injuries are an important problem in the Netherlands and Europe.
- There exist large international differences in the economic and health impact of injuries, which can only partly be attributed to differences in injury incidence.
- The methods to assess the economic and health impact of injury, presented in this thesis, may support future economic evaluations and injury control policies in the Netherlands and Europe.

Recommendations

- Standardization methods of hospital data as presented in this thesis, including our method to calculate health care costs of injury, should be made available for worldwide application.
- Empirical studies with large samples are recommended for further validation and improvement of injury indicators.
- Measurement of functional outcome after injury should use a longitudinal design. For non-hospitalized injury patients assessment moments at 1, 3, and 6 months post-injury are recommended. For hospitalized patients assessments at 3, 12 and 24 months post-injury should be used.
- Descriptive burden of disease and cost of illness studies should not discount future health effects and costs.
- Future research should investigate the causes of the high variation in injury incidence, functional recovery, and health care costs in elderly females, adult males, and children, to support prevention programs and to reduce the still unacceptable burden of injury in the Netherlands and Europe.

References

1. Schwermann, T., M. Grotz, M. Blanke, S. Ruchholtz, et al., [Evaluation of costs incurred for patients with multiple trauma particularly from the perspective of the hospital] Evaluation der Kosten von polytraumatisierten Patienten insbesondere aus der Perspektive des Krankenhauses. Unfallchirurg, 2004. 107(7): p. 563-74.
2. Meerding, W.J., S. Mulder, and E.F. Van Beeck, Incidence and costs of injuries in the Netherlands. Eur J Public Health, 2006. Online available.
3. Miller, T.R. and D.C. Lestina, Patterns in US medical expenditures and utilization for injury, 1987. Am J Public Health, 1996. 86: p. 89-93.
4. Mathers, C.D., R. Penm, C. Stevenson, and R. Carter, Health system costs of diseases and injury in Australia, 1993-4, in Health and Welfare Expenditure Series No 2, AIHW, Editor. 1998: Canberra.
5. Meerding, W.J., C.W. Looman, M.L. Essink-Bot, H. Toet, et al., Distribution and determinants of health and work status in a comprehensive population of injury patients. J Trauma, 2004. 56(1): p. 150-61.
6. Hoeymans, N., H. LIndert van, and G.P. Westert, The health status of the Dutch population as assessed by the EQ-6D. Qual Life Res, 2005. 14(3): p. 655-663.
7. Jansen S.J., Stiggelbout A.M., Nooij M.A., Noordijk E.M., et al., Response shift in quality of life measurement in early-stage breast cancer patients undergoing radiotherapy. Qual Life Res, 2000. 9: p. 603-615.
8. Polinder, S., W.J. Meerding, H. Toet, M.E. van Baar, et al., A surveillance based assessment of medical costs of injury in Europe: phase 2. 2004, ErasmusMC and Consumer Safety Institute: Http:/www.euroipn.org/grd/attachments/80/final%20report.pdf.
9. Essink-Bot, M.L. and G.J. Bonsel, How to derive disability weights, in Summary measures of population health: concepts, ethics, measurement and applications, C.J.M. Murray, et al., Editors. 2002, World Health Organization: Geneva.
10. Van Beeck, E.F., C.F. Larsen, R.A. Lyons, W.J. Meerding, et al., Draft guidelines for the conduction of empirical studies into injury-related disability, European Association for Injury Prevention and Safety Promotion, Editor. 2005, consumer Safety Institute: Amsterdam.
11. Baldry Currens, J.A. and T.J. Coats, The timing of disability measurements following injury. Injury, 2000. 31: p. 93-98.
12. Kopjar, B., The SF-36 health survey: a valid measure of changes in health status after injury. Inj Prev, 1996. 2(2): p. 135-9.
13. Holbrook, T.L., J.P. Anderson, W.J. Sieber, D. Browner, et al., Outcome after major trauma: discharge and 6-month follow-up results form the Trauma Recovery Project. J Trauma, 1998. 45: p. 415-323.
14. Holbrook, T.L., J.P. Anderson, W.J. Sieber, D. Browner, et al., Outcome after major trauma: 12-month and 18-month follow-up results from the Trauma Recovery Project. J Trauma, 1999. 46(5): p. 765-71.
15. Michaels, A.J., C.E. Michaels, J.S. Smith, C.H. Moon, et al., Outcome from injury: general health, work status, and satisfaction 12 months after trauma. J Trauma, 2000. 48(5): p. 851-850.
16. Aitken, M.E., J.M. Tilford, K.W. Barrett, J.G. Parker, et al., Health status of children after admission for injury. Pediatrics, 2002. 110: p. 337-342.
17. Mackenzie, E.J., M.L. McCarthy, J.F. Ditunno, C. Forrester-Staz, et al., Using the SF-36 for characterizing outcome after multiple trauma involving head injury. J Trauma, 2002. 52: p. 527-534.
18. Inaba, K., M. Goecke, P. Sharkey, and F. Brenneman, Long-term outcomes after injury in the elderly. J Trauma, 2003. 54(3): p. 486-91.
19. Baldry Currens, J.A., Evaluation of disability and handicap following injury. Injury, 2000. 31: p. 99-106.
20. Sturms, L.M., C.K. Sluis, J.W. Groothoff, H.J. Duis ten, et al., Young traffic victims' long-term helath-related quality of life: child self-reports and parental reports. Arch Phys Med Rehabil, 2003. 84: p. 431-6.
21. Hennessy, S. and P. Kind, Measuring health status in children: developing and testing a child-friendly version of EQ-5D. 2002, Outcomes Research Group, Centre for Health Economics, University of York.

22. Cameron, C.M., E.V. Kliewer, D.M. Purdie, and R.J. McClure, Long term health outcomes after injury in working age adults: a systematic review. J Epidemiol Community Health, 2006. 60: p. 341-344.
23. Mathers, C., T. Vos, and C. Stevenson, The burden of disease and injury in Australia, AIHW, Editor. 1999, AIHW: Canberra.
24. Murray, C.J.L. and A.D. Lopez, The Global Burden of Disease: a comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Global Burden of Disease and injury series. 1996, Boston: The Harvard School of Public Health.
25. Kruijshaar, M.E., Data consistency in summary measures of population health (thesis). 2004, Erasmus University: Rotterdam.
26. Meerding, W.J., describing health and medical costs, and the economic evaluation of health care: applications in injuries and cervical cancer (thesis). 2004, Erasmus University: Rotterdam.
27. Gillespie, L.D., W.J. Gillespie, M.C. Robertson, S.E. Lamb, et al., Interventions for preventing falls in elderly people (Cochrane Review), in The Cochrane Library, issue 1. 2003, Update Software: Oxford.
28. McClure, R.J., M. Stevenson, and S. McEvoy, The scientific basis of injury prevention and control. 2004, Melbourne: IP communications.

Acknwledgements

Chapter 2-5, and 8 are based on data of the Eurocost project. The project was conducted as a collaborative effort of experts; the 'Eurocost reference group'.

Eurocost reference group

Robert Bauer, Austrian Institute for Home and Leisure Safety / Sicher Leben, Austria
Claus Larsen, Copenhagen University Hospital, Denmark
Ronan Lyons, The School of Medicine, University of Wales Swansea, UK
Tim McCarthy, Ministry of Health, Ireland
Catherine Pérez, Municipal Institute of Public Health, Spain
Eleni Th. Petridou, School of Medicine, University of Athens, Greece
Alessio Pitidis, Department of Environment and Primary Prevention, National Institute of Health, Italy
Hidde Toet, Consumer Safety Institute, the Netherlands
Anne Mette Tranberg Kejs, National Institute of Pubic Health, Denmark
Johannes Wiik, Norwegian Institute of Public Health, Norway

The studies described in this thesis were financially supported by the European Commission under the Public Health Program (chapter 2-5, 8), and by the Ministry of Health, Welfare and Sports (chapter 6 and 7).

Summary

Samenvatting

Dankwoord

Curriculum vitae

List of publications

Summary

Injuries are a persistent and dynamic public health problem. Injuries are a leading cause of death and disability throughout the world and pose a serious burden on society because of the considerable health care costs involved.

Injuries range from high frequency, minor injuries (e.g. superficial injuries) to low frequency, major injuries (e.g. polytrauma patients). As a consequence, injuries result in various arrays of functional consequences and recovery patterns. The heterogeneity of the problem puts specific demands on data sources and analytical tools for the measurement and valuation of incidence, functional outcome, and medical costs of injury in a national and international context. Analytical tools for describing the health and economic impact of disease and injury are the burden of disease (BOD) and cost of illness (COI) methodology. Consideration of the economic and health impact of injuries may serve to identify controllable determinants and develop preventive interventions. This calls for accurate public health surveillance systems to be used as a basis for research and policy.

The following research questions are addressed in this thesis:

1) Can the international comparability of injury incidence data be improved?
2) What are the medical costs of injury in European countries and can international variation be explained?
3) What is the health impact of injury in terms of functioning and burden of disease, and can international variation be explained?

Injury incidence

Injury incidence data provide a basis for determining priorities, emerging issues, and trends in injury. Internationally, injury incidence is estimated with the help of hospital-based surveillance systems and discharge registers. The quality and consistency of injury incidence data is crucial for valid burden of disease (BOD) and cost of illness (COI) analyses.

There are, however, a number of important issues to be considered in estimating injury incidence using hospital based data sources. **Chapter 2** describes methodological challenges and devises solutions to compare injury incidence across countries. Comparisons can be disturbed by cross-national differences in registration practice, health systems, and health care policy. We showed that standardisation of the operational definition of 'injury', inclusion and exclusion criteria, and clustering of injury groups improved the international comparability of injury incidence.

Injury indicators were developed and tested in **chapter 3**. They can be used to standardize injury severity in order to detect real rather than artificial variation in injury incidence between countries. We showed that indicators based on outcome criteria (disability weights) and anatomical criteria (long bone fractures and selected radiological verifiable fractures (SRVF)) improved the comparability of hospital based injury incidence

data, by comparing more homogeneous patient groups in terms of health care consumption.

Economic impact of injury

Medical costs combine incidence and severity (in terms of health care consumption) of injury. Costs enable rapid comparisons among very different types of injury. Comprehensive and detailed information on health care costs show at a glance where costs might potentially be saved or where interventions are most needed. Furthermore, an international comparison can reveal common problems for several countries and specific problems for individual countries. **Chapter 4** describes the development and application of a uniform method to calculate medical costs of injury in eight European countries. Large international differences in health care costs of injury were observed. At the upper end of the spectrum, Austria has a high clinical incidence and cost per capita for all injury groups, in particular compared to Ireland and the Netherlands. Major constituents of high per capita costs were a high incidence of severe injuries (Austria, Greece), health system and trauma policy characteristics (high admission rates and hospital length of stay in Austria and Norway), and high unit costs of health care (Norway, Denmark). International comparisons of ED based surveillance data, added with data on health care consumption and medical costs, can provide clues for injury prevention and improving the efficiency of emergency medicine.
Chapter 5 shows that the pattern of costs per capita of hospitalised patients by age, sex, injury type and external cause is broadly similar in all countries that were studied. Elderly aged 65 and over, especially women, consume a large part of hospital resources due to injuries (more than one third), mainly caused by hip fractures and fractures of the knee and lower leg. Young children en male adolescents are also high-cost groups. Home and leisure, sport, and occupational injuries combined make a major contribution to the total hospital costs of injury in Europe.

Health impact of injury

Quantitative data on the functional outcome of injury, and of its major determinants, are important to direct the development of preventive interventions and trauma care. To make valid estimates of the burden of disease due to injury sound epidemiological data on the incidence, severity and duration of the health consequences (functional outcome) of injuries are necessary. Functional outcome encompasses the level of body functions, activities and participation in life situations. Because of the many functional sequelae and recovery patterns of injuries, the measurement of functioning is a necessary but also challenging task. Generic (not disease-specific) instruments thereby enable a uniform comparison of injuries among each other and with other health problems.
Chapter 6 reports on a large follow-up study on functional outcome in a population of hospitalized and non-hospitalized non-fatal injury patients (aged 15+) who visited an

Emergency Department in the Netherlands. Functional outcome was assessed at 2½, 5, 9, and 24 months post-injury with the EQ-5D health status measure. Health status of non-hospitalised patients was equal to the general population's health 5 months after injury (EQ-5D summary score: 0.87), whereas patients with a long hospital stay still reflected a significant degree of functional limitations two years after injury (EQ-5D summary score: 0.67). Apart from hospitalisation, also high age, female sex, specific types of injury (hip fracture, spinal cord injury, and fractures knee/lower leg), and comorbidity were independent predictors of poor functioning in the long-term. For instance, patients with two or more comorbidities have 9 months post injury an EQ-5D score that is 0.20 lower than for patients without comorbidities.
Chapter 7 focuses on the functional outcome of injured children aged 5-14 years in the Netherlands and describes predictors for sub-optimal functioning in the long term. Functional outcome was assessed with the EQ-5D health status measure. The vast majority of injured children reported full recovery already within 3-5 months after the injury, but a subgroup of patients (8%) has residual disabilities 9 months after the injury. Female gender and hospitalisation were significant and independent predictors for long-term disability. Girls had a 3-fold risk and hospitalised children had a 3 to 5-fold risk for sub-optimal functioning nine months after the injury.
Subsequently, in **chapter 8** we integrate data on premature mortality and years lived with disability to describe the burden of disease of a population in a single metric, namely disability adjusted life years (DALYs). We assessed the burden of disease as a consequence of injury in seven European countries. Austria has the largest burden of disease resulting from injuries (25 DALY/1000 persons), followed by Denmark, Norway and Ireland (17-20 DALY/1000 persons). In the Netherlands, England and Wales the total burden of disease due to injuries was relatively low (12 DALY/1000 persons). These marked differences were due to a high variation in both premature mortality and disability between the countries. Males aged 25-44 years caused one third of the total injury burden in these seven European countries, mainly due to traffic and intentional injury. Spinal cord injury and skull brain injury contributed most to the burden of disability (60%), mainly due to permanent disability.

Health consequences and costs of injuries extend over many years. As a result, in BOD and COI studies future costs and health benefits are often discounted, thus giving less weight to future events. In **chapter 9** an overview is given of the arguments for discounting, the appropriate discount rate, and the shape of the discount function. With empirical research we observed a significantly stronger time preference (i.e. higher discount rates) for health effects than for costs. We also analyzed the influence of life expectancy on time preferences, as an objective measure for relevant differences (between people) over time. Respondents with a higher expected overall life expectancy reported a higher time preference for health effects. This indicates that increasing life expectancy and decreasing marginal valuation of additional QALYs over time might serve as a theoretical basis for discounting future health effects from a societal perspective. It is an important topic, since the choice of the discount rate used can alter the results of BOD and COI studies (and of economic evaluation studies) considerably. Discounting reduces the importance of the burden of diseases and injury in children relative to elderly. We therefore recommend to avoid discounting future costs and health effects in descriptive burden of disease and cost of illness studies.

In **chapter 10** the findings are summarized and discussed, including the relative contribution of burden of disease and cost of illness studies to the prioritization of health care.
We conclude that the economic and health impacts of injury are complementary indicators for national and international health policy. Ideally, costs and burden of injury should be analysed in a combined perspective. Data on disease burden and health care costs are both an essential input to economic evaluation studies, which provide insight into the (potential) changes in costs and population health as a result of a particular intervention.
With injury, a major cause of morbidity and mortality worldwide, policy makers face a major task in seeking to choose the best interventions to implement. Economic evaluations of injury prevention and control programs may offer useful information regarding the efficiency of alternative sources of action. Together with concerns of equity and political feasibility, efficiency considerations help answer questions about how to allocate injury prevention and trauma care resources in such a way as to maximise the returns on investment. The methods to assess the economic and health impact of injury, presented in this thesis, may support future economic evaluations and injury control policies in the Netherlands and Europe. We applied these methods in the framework of an integrated model assessing the balance between costs and health effects of fall reducing interventions in the elderly, and showed that at least one of these interventions is potentially cost saving.

The main conclusions and recommendations of this thesis are as follows:

- International standardization methods of hospital-based data systems and the use of injury indicators improve the comparability of injury incidence data between countries and should be made available for worldwide application. Validation studies with large samples are recommended for further justification and development of injury indicators.
- Medical costs of injury compute the combined effects of the incidence and severity of injury, and therefore enable rapid comparisons among types of injury that differ with respect to severity and health care need. Our surveillance based method for calculating medical costs of injury should be further applied internationally, allowing international comparisons between countries and pooling of country-specific data of health care costs.
- The EQ-5D instrument is a feasible and valid instrument for the measurement of functioning and disability in injury patients of all severity levels in the age of five

years and older. Measurement of functional outcome after injury should be performed with an adapted longitudinal design, which depends on the severity of the injury studied.

- In terms of costs, functional consequences and burden of disease, injuries are a sizeable problem in the Netherlands and Europe. The dynamic nature of injuries, as illustrated in this thesis, makes them one of the most challenging fields for public health. More detailed determinant studies and cost-effectiveness analyses on risk groups (e.g. elderly) should be performed, to support prevention programs and to reduce the still unacceptable burden of injury in the Netherlands and Europe.

Samenvatting

Acute lichamelijke letsels, veroorzaakt door ongevallen, zelfbeschadiging of geweld, vormen een altijd aanwezig en dynamisch volksgezondheidsprobleem. Elk jaar raken alleen al in Nederland ca 1 miljoen mensen zodanig gewond dat zij onderzocht en behandeld moeten worden op de Spoed Eisende Hulp (SEH) van een ziekenhuis. Acute lichamelijke letsels (verder benoemd als 'ongevalsletsels') hebben heel verschillende functionele gevolgen en herstelpatronen variërend van veel voorkomende niet-levensbedreigende letsels (b.v. oppervlakkige letsels, open wonden) tot minder voorkomende levensbedreigende letsels (b.v schedelhersenletsels, heupfracturen). Deze heterogeniteit stelt hoge eisen aan empirische data en meetmethoden om de functionele gevolgen en zorgkosten van ongevalsletsels nationaal en internationaal in kaart te kunnen brengen. Gegevens over het voorkomen van letsels en (internationale) verschillen hierin kunnen worden gebruikt om vermijdbare gezondheidsschade door ongevallen te identificeren. Gegevens over de functionele gevolgen en zorgkosten van letsels zijn van belang voor het identificeren van patiëntengroepen met een hoog risico op ernstige en blijvende beperkingen en/of een grote zorgbehoefte. Informatie hierover kan bijdragen aan het doelgericht ontwikkelen en evalueren van preventieve interventies en van traumazorg.
De volgende onderzoeksvragen staan centraal in dit proefschrift:

1) Hoe kan de internationale vergelijkbaarheid van letselregistratiegegevens worden verbeterd?
2) Wat zijn de medische kosten van ongevalsletsels in Europa en hoe kunnen internationale verschillen worden verklaard?
3) Wat zijn de functionele gevolgen en ziektelast van ongevalsletsels en hoe kunnen internationale verschillen worden verklaard?

Letselregistratiegegevens

Nationale en internationale registratiesystemen in ziekenhuizen zijn belangrijke gegevensbronnen over het voorkomen van ongevalsletsels en trends hierin. De kwaliteit en consistentie van deze registratiesystemen zijn van groot belang voor het maken van onderling vergelijkbare schattingen van het voorkomen van ongevalsletsels en de hiermee gepaard gaande medische kosten en functionele gevolgen. In **hoofdstuk 2** worden methodologische knelpunten besproken met betrekking tot het gebruik van letselregistratiegegevens in ziekenhuizen voor internationale vergelijkingen. Een aantal methoden wordt aangereikt om schattingen van het voorkomen van ongevalsletsels internationaal vergelijkbaar te maken (standaardisatie).
In ziekenhuisregistraties geobserveerde internationale verschillen in het voorkomen van ongevalsletsels kunnen worden veroorzaakt door verschillen in registratiepraktijk en/of gezondheidszorgsystemen. Letselindicatoren hebben als doel om patiëntgroepen te definiëren, waarvan het zorggebruik met name bepaald wordt door de aard en/of ernst van het letsel. Deze patiëntgroepen zijn minder gevoelig voor verschillen in registratiepraktijk, en gezondheidszorgsystemen en geven daarmee een beter inzicht in de 'werkelijke' verschillen

in het voorkomen van ongevalsletsels tussen landen. Letselindicatoren zijn getest met behulp van internationale letselregistratiegegevens in **hoofdstuk 3**. Hieruit kwam naar voren dat het gebruik van indicatoren gebaseerd op anatomische kenmerken van het letsel of het verwachte effect op de gezondheidstoestand de internationale vergelijkbaarheid van letselregistratie gegevens vergroot. De uiteindelijke doelstelling van het onderzoek en de beschikbaarheid van de gegevens zijn vervolgens maatgevend voor de keuze van de indicator.

Medische kosten van ongevalsletsels

Gezien de heterogeniteit van de oorzaken én de gevolgen (qua ernst en zorgbehoefte) van ongevalsletsels, kunnen medische kosten een nuttige samengestelde maat zijn om het relatieve belang van specifieke ongevalcategorieën weer te geven. Een internationale vergelijking van de kosten van ongevallen kan gemeenschappelijke internationale problemen aan het licht brengen, maar ook problemen die specifiek zijn voor een land. Wij hebben een methode ontwikkeld die het mogelijk maakt om met behulp van ziekenhuisregistratiesystemen de zorgkosten van ongevallen binnen Europa op een methodologisch consistente wijze te berekenen. In **hoofdstuk 4** wordt de ontwikkeling en toepassing van deze methode besproken voor acht Europese landen. Ook wordt getest in welke mate een letselindicator (gebaseerd op een selectie van botbreuken) de vergelijkbaarheid van de gegevens vergroot.

Er worden grote internationale verschillen in zorgkosten voor ongevallen waargenomen. Van de acht onderzochte Europese landen heeft Oostenrijk de hoogste en hebben Nederland en Ierland de laagste zorgkosten ten gevolge van ongevallen. Belangrijke veroorzakers van hoge kosten zijn het veel voorkomen van ernstige letsels (Oostenrijk en Griekenland), verschillen in gezondheidszorgsystemen en traumazorg (hoge opnamekans en opnameduur voor Oostenrijk en Noorwegen), en hoge kostprijzen voor de gezondheidszorg (Noorwegen en Denemarken).

De verdeling van de zorgkosten naar leeftijd, geslacht, letseltype en soort ongeval levert een vergelijkbaar patroon op voor alle deelnemende landen in **hoofdstuk 5**. Mensen ouder dan 65 jaar, in het bijzonder vrouwen, nemen een groot deel (meer dan een derde) van de totale zorgkosten voor hun rekening, met name veroorzaakt door botbreuken (heup- en knie/onderbeen). Jonge kinderen en mannen van middelbare leeftijd zijn ook groepen met relatief hoge medische kosten. Met name privé- en sportongevallen leveren een grote bijdrage aan de totale zorgkosten van ongevallen in Europa.

Functionele gevolgen en ziektelast van ongevalsletsels

Naast zorgkosten zijn ook gegevens over de functionele gevolgen en de ziektelast van ongevallen van belang voor het doelgericht ontwikkelen van preventieve interventies en van traumazorg. Vanwege de heterogeniteit in functionele gevolgen en herstelpatronen bij ongevalsletsels, is het meten van beperkingen op een consistente en vergelijkbare manier niet alleen noodzakelijk maar ook uitdagend. Uit eerder onderzoek is gebleken dat met

generieke (niet-ziektespecifieke) instrumenten zoals de EuroQol het goed mogelijk is om de gevolgen van ongevalsletsels op een eenduidige wijze met elkaar en met andere gezondheidsproblemen te vergelijken. Wij hebben functionele gevolgen gemeten bij een brede populatie ongevalspatiënten die zijn behandeld op de spoedeisende hulp in Nederland, 2½, 5, 9 en 24 maanden na het ongeval. We gebruikten de EuroQol, een generiek instrument waarmee beperkingen worden gemeten ten aanzien van mobiliteit, zelfverzorging, dagelijkse activiteiten, pijn of ongemak, en angst of somberheid. De EuroQol scoreprofielen kunnen worden vertaald in een somscore (utiliteit) tussen 0 en 1 waarmee de algehele kwaliteit van de gezondheidstoestand wordt beschreven.
De gezondheidstoestand van ongevalspatiënten ouder dan 15 jaar wordt besproken in **hoofdstuk 6**. Vijf maanden na het ongeval was de gezondheidstoestand van niet opgenomen ongevalspatiënten weer gelijk aan de gezondheidstoestand van de algemene bevolking (EuroQol somscore: 0.87). Ongevalspatiënten die voor langere tijd opgenomen zijn geweest (> 7 dagen), ervaren twee jaar na het ongeval nog steeds aanzienlijke gezondheidsbeperkingen (EuroQol somscore: 0.67). Leeftijd (65+), Geslacht (vrouwen), specifieke letsels (heupfractuur, ruggenmergletsel, schedel-hersenletsel), en de aanwezigheid van andere ziekten (comorbiditeit) zijn onafhankelijke voorspellers voor een verhoogd risico op langdurige gevolgen van een ongeval. Comorbiditeit resulteert bijvoorbeeld 9 maanden na het ongeval nog in een gemiddelde afname van de EuroQol score van 0.20. **Hoofdstuk 7** gaat specifiek over de functionele gevolgen van ongevallen voor kinderen in de leeftijd van 4 tot 15 jaar. Het merendeel van de kinderen herstelt binnen een periode van 3-5 maanden van het letsel ten gevolge voor een ongeval. Een kleine groep kinderen (8%), heeft 9 maanden na het ongeval nog steeds gezondheidsproblemen. Kinderen die opgenomen zijn geweest hebben een 3 tot 5 keer hogere kans om 9 maanden na het ongeval nog functionele beperkingen te ervaren ten gevolge van het ongeval en meisjes hebben een 3 keer hogere kans dan jongens op langdurige beperkingen.

In **hoofdstuk 8** hebben we voor 7 Europese landen Disability-Adjusted Life Years (DALYs) berekend. De DALY is een samengestelde volksgezondheidsmaat die gegevens over morbiditeit en mortaliteit combineert. In Oostenrijk wordt de hoogste ziektelast ten gevolge van ongevallen gevonden (25 DALY/1000 inwoners), gevolgd door Denmarken, Noorwegen en Ierland (17-20 DALY/1000 inwoners). In Nederland, Engeland en Wales wordt een twee keer zo lage ziektelast gevonden vergeleken met Oostenrijk (12 DALY/1000 inwoners). De verschillen worden veroorzaakt door grote variatie in vroegtijdige sterfte én verschillen in functionele gevolgen. Mannen in de leeftijd van 25-44 jaar nemen een derde van de totale ziektelast door ongevallen voor hun rekening, voornamelijk veroorzaakt door verkeersongevallen en geweld. Doordat veel wervelkolom en schedel-hersenletsel patiënten permanente gevolgen ervaren van het ongeval, veroorzaken zij een aanzienlijk deel (60%) van de totale ziektelast.

De kosten en functionele gevolgen van ongevallen vinden vaak verspreid over een aantal jaren plaats. Disconteren wordt gebruikt om toekomstige gezondheidseffecten en kosten terug te rekenen naar huidige waarden. In **hoofdstuk 9** wordt een overzicht gegeven van de discussie die in de literatuur gaande is over disconteren. In een empirische studie naar disconteren is een significant hogere disconteervoet voor gezondheidseffecten dan voor kosten waargenomen. Uit ons onderzoek blijkt dat de gerapporteerde disconteervoet voor effecten wordt beïnvloedt door de levensverwachting: personen met een hogere verwachte levensverwachting rapporteerden een hogere disconteervoet voor gezondheidseffecten. Dit impliceert dat wanneer de levensverwachting in de toekomst toe neemt, de respondenten het belangrijker vinden dat de effecten van gezondheidszorgvoorzieningen op korte termijn plaatsvinden. Het vinden van een passende disconteervoet voor effecten en kosten is belangrijk, aangezien de wijze van disconteren de uiteindelijke onderzoeksresultaten sterk kan beïnvloeden. Disconteren is van belang wanneer een vergelijkende analyse wordt uitgevoerd van alternatieve technologieën of scenario's. Wij adviseren om toekomstige gezondheidseffecten en kosten niet te verdisconteren in beschrijvende studies naar de kosten en ziektelast van ongevalspatiënten.

Het proefschrift wordt afgesloten met een algemene discussie (**hoofdstuk 10**). De belangrijkste resultaten worden kort samengevat en de bevindingen uit dit proefschrift worden geïntegreerd in een discussie over het relatieve belang van gegevens over ziektelast en kosten van ziekte voor prioriteitstelling in de gezondheidszorg. Beide zijn noodzakelijk en complementair voor beslissingen aangaande de verdeling van zorgmiddelen. Met gegevens over ziektelast en kosten van ziekten kunnen ziekten, risicofactoren, en bevolkingsgroepen geïdentificeerd worden met de grootste behoefte aan zorginterventies. Verder zijn in de discussie de bevindingen in dit proefschrift geïntegreerd met een discussie over het belang van ziektelast- en kostenstudies enerzijds, en van economische evaluaties anderzijds. Ziektelast- en kostenstudies geven essentiële informatie over de (on)gelijkheid in gezondheid respectievelijk de toegang tot gezondheidszorg, terwijl economische evaluaties informatie geven over de efficiëntie van gezondheidszorg. In de discussie wordt een voorbeeld van een economische evaluatie gegeven voor maatregelen ter voorkomen van valongevallen bij ouderen.

Conclusies en aanbevelingen

- Standaardisatie methoden van letselregistraties in ziekenhuizen en de toepassing van letsel indicatoren verbeteren de internationale vergelijkbaarheid van ongevalgegevens. Voor de verdere ontwikkeling en onderbouwing van letsel indicatoren zullen grotere studies moeten worden uitgevoerd.
- Gezien de heterogeniteit van de oorzaken en de gevolgen (qua ernst en zorgbehoefte) van ongevallen, kunnen de kosten van ongevallen een nuttige samengestelde maat zijn om het relatieve belang van specifieke ongevalcategorieën aan te geven. Onze methode, waarmee je aan de hand van registratie systemen zorgkosten van ongevallen berekent, zal internationaal verder moeten worden toegepast, wat uitgebreidere internationale vergelijkingen mogelijk zal maken.

- Het is goed mogelijk om de functionele gevolgen van verschillende ongevalsletsels op een valide wijze te meten en te vergelijken met de EuroQol bij volwassenen en kinderen van 5 jaar en ouder. Het meten van functionele gevolgen van ongevalspatiënten moet worden uitgevoerd aan de hand van een longitudinaal design, afhankelijk van de ernst van het letsel dat wordt onderzocht.
- Uit het oogpunt van zorgkosten, functionele gevolgen en ziektelast zijn ongevallen een belangrijk probleem in Nederland en Europa. De dynamiek binnen het terrein van lichamelijke letsels veroorzaakt door ongevallen, zoals geïllustreerd in dit proefschrift, maken dit veld één van de grootste uitdagingen op het gebied van de volksgezondheid. Meer onderzoek moet worden uitgevoerd naar risicogroepen die in belangrijke mate bijdragen aan de ziektelast en kosten van ongevallen, om preventieve maatregelen te kunnen ondersteunen.

Dankwoord

Met veel plezier heb ik dit proefschrift geschreven. Terugblikkend is het een enorm stimulerende en leerzame periode voor me geweest. Promoveren doe je gelukkig niet alleen. Zonder advies, hulp en steun van een groot aantal mensen was dit proefschrift niet ontstaan. Allen wil ik hiervoor bedanken, een aantal van hen in het bijzonder.

Allereerst gaat mijn dank uit naar mijn co-promotoren Ed en Willem Jan.
Ed, ik heb veel bewondering voor je kennis en inzicht, je enthousiasme en je warme persoonlijkheid. Ook in drukke tijden wist je altijd tijd vrij te maken voor mij. Ik heb ontzettend veel van je geleerd en mede dankzij jou ben ik waar ik nu ben. Dank voor al jouw inbreng en je enthousiasme! Willem Jan, besprekingen met jou waren altijd erg constructief. Bespreken wat we moesten bespreken en dan weer hard aan de slag. Jouw hulp de afgelopen jaren is voor mij van grote waarde geweest. Je visie bij het tot stand komen van artikelen was erg leerzaam. Veel succes met je nieuwe baan.
Dik Habbema, mijn promotor, net als veel voorgangers roem ik je scherpe inzicht. Met een simpele vraag of opmerking wist je ingewikkelde problemen terug te brengen tot begrijpelijke proporties. De afronding van mijn proefschrift ging mede door jouw inbreng als een speer.
De leden van de promotiecommissie, Professor Bonsel, Professor Rutten en Professor Patka dank ik voor het lezen en beoordelen van mijn proefschrift.

Dit proefschrift zou nooit tot stand zijn gekomen zonder de samenwerking met Consument en Veiligheid en de Eurocost werkgroep. Saakje Mulder en Hidde Toet (Consument en Veiligheid) dank ik voor onze prettige samenwerking in het ongevallenonderzoek. Professor Lyons, dear Ronan, I am honoured with your willingness to participate in the defence of my thesis. I would like to thank Eleni Petridou, Robert Bauer, Catherine Perez, Claus Falck Larsen, Alessio Pitidis, Johannes Wiik for your collaboration in the Eurocost project and for your stimulating contributions during the fruitful Eurocost meetings. Furthermore, I would like to thank Delia Alexe and Nick Dessypris for their valuable contribution in the internal review process of several papers.

Beste Werner, mijn belangstelling voor onderzoek is gewekt onder jouw bezielende begeleiding van mijn afstudeerscriptie. Het enthousiasme waarmee jij de wetenschap bedrijft werkt aanstekelijk!
Graag wil ik de co-auteurs Marie-Louise, Caspar, Juanita en Job bedanken voor hun bijdrage aan de artikelen die in dit proefschrift zijn opgenomen.

Zonder onderzoekscollega's geen plezier. De afgelopen 4 jaar op MGZ hadden er heel anders uitgezien zonder de gezelligheid van collega's.
Tinneke en Eveline, betere collega's kun je je niet wensen. Sociaal, gezellig en attent. Ik vind het een eer dat jullie aan mijn zijde willen staan tijdens de promotieplechtigheid! Het is fijn altijd bij jullie binnen te kunnen lopen voor de 'koetjes en kalfjes', maar ook op momenten dat

ik het moeilijk had. Jullie belangstelling voor mijn proefschriftvorderingen, maar met name voor mij als persoon is hartverwarmend.
En dan natuurlijk Esther. Als kamergenoten hebben we al een hoop lief en leed gedeeld, en gelukkig vooral veel gelachen. Twee zwangere dames op één kamer. Leuk dat we naast onderzoeksaangelegenheden nu ook zwangerschaps- en baby besognes delen.
Margriet, bedankt voor je belangstelling, luisterend oor en altijd weer de juiste opmerking om weer vol enthousiasme door te kunnen gaan. Erg jammer dat je weg bent bij MGZ.
Ik dank mijn CMB-collega's en speciaal René en Ewout. René, jouw toegankelijkheid, vriendelijkheid en warme belangstelling maken jou tot een heel fijn persoon om mee samen te werken. Ewout, bedankt voor het delen van je kennis en voor je laagdrempeligheid.
Bij computers gaat alles automatisch maar niets vanzelf. Daarom wil ik Kees en Peter hartelijk danken dat ik altijd zo goed werd geholpen als ik weer eens computer stress had.

Lieve familie en vrienden, al hebben jullie waarschijnlijk niet veel 'last' gehad van mijn proefschrift, dit is wel een mooie gelegenheid om jullie te bedanken dat jullie er voor mij zijn. Jullie zijn bijzonder en onmisbaar. Tegen al mijn familie en vrienden kan ik oprecht zeggen dat ik niet zonder jullie kan. Bedankt voor jullie vriendschap, betrokkenheid en liefde.

Paps en mams, bedankt voor alle liefde, vertrouwen en ondersteuning, wanneer dat nodig was. Ik houd van jullie. Bedankt dat jullie mij de mogelijkheid hebben gegeven om datgene te doen wat ik ambieer en om mijn eigen pad te bewandelen!

Lieve, lieve Arwen. Samen kunnen we de hele wereld aan! Jij maakt mijn leven in alle opzichten zoveel leuker. Waar grote liefde is, daar zijn altijd wonderen… Lieve Cato, ik houd van jou helemaal tot aan de maan – en terug!

Bedankt! Suzanne

Curriculum Vitae

Suzanne Polinder werd op 12 juni 1977 geboren te Kampen. Ze behaalde in 1995 haar VWO diploma aan het Johannes Calvijn Lyceum te Kampen. Van 1995 tot 1999 deed zij de opleiding HBO-verpleegkunde aan het Windesheim te Zwolle. In het kader van deze studie volbracht zij haar afstudeerstage in Pakistan. Vervolgens startte ze haar studie Beleid en Management Gezondheidszorg aan de Erasmus Universiteit. In 2003 behaalde ze haar doctoraal diploma. Tijdens haar studie heeft ze gewerkt als verpleegkundige op de afdeling nefrologie in het Sint Franciscus Gasthuis te Rotterdam. In augustus 2002 werd ze aangesteld als junior onderzoeker bij het Instituut Maatschappelijke Gezondheidszorg van het Erasmus Medisch Centrum Rotterdam. Zij was als gezondheidseconoom betrokken bij kosten-effectiviteitsstudies van nieuwe behandelingen voor onder andere slokdarmkanker en IVF. Ook was zij betrokken bij een internationaal onderzoeksproject naar de kosten van ongevallen in Europa en een project naar de kwaliteit van leven van ongevalpatiënten in Nederland. Uit beide laatstgenoemde projecten is dit proefschrift voortgekomen.

Suzanne is getrouwd met Arwen Korteweg en samen hebben zij een dochter, Cato (2006).

List of publications

Publications and manuscripts reprinted in this thesis

Lyons RA, Polinder S, Larsen CF, Mulder S, Meerding WJ, Van Beeck EF, and the Eurocost reference group. Methodological issues in comparing injury incidence across countries. International Journal of Injury control and Safety Promotion. 2006; 13: p. 63-70.

Polinder S, Meerding WJ, Lyons RA, Toet H, Haagsma JA, Petridou E, Mulder S, van Beeck EF, and the Eurocost reference group. International variation in clinical injury incidence in ten European countries: performance of indicators based on health care, anatomical and outcome criteria? Submitted.

Meerding WJ, Polinder S, Lyons RA, Toet H, Mulder S, van Beeck EF, and the Eurocost reference group. Incidence, health care consumption and costs of home and leisure injury in 7 European countries. Submitted.

Polinder S, Meerding WJ, van Baar ME, Toet H, Mulder S, van Beeck EF, and the Eurocost reference group. Cost estimation of injury related hospital admissions in ten European countries. Journal of Trauma. 2005. 59: 1283-1291.

Polinder S, van Beeck EF, Essink-Bot ML, Toet H, Looman CWN, Mulder S, Meerding WJ. Functional outcome at 2½, 5, 9 and 24 months after injury in the Netherlands. Journal of Trauma. In press.

Polinder S, Meerding WJ, Toet H, Mulder S, Essink-Bot ML, van Beeck EF. Prevalence and prognostic factors of disability after childhood injury. Pediatrics. 2005. 116: 810-817.

Polinder S, Meerding WJ, Mulder S, Petridou E, van Beeck EF, and the Eurocost reference group. Assessing the burden of injury in six European countries. Bulletin of the World health Organization. In press.

Polinder S, Meerding WJ, van Exel NJ, Brouwer WBF. Societal discounting of health effects in cost-effectiveness analyses: the influence of life expectancy. Pharmacoeconomics. 2005. 23: 791-802.

Other publications and manuscripts

Polinder S, Homs MY, Siersema PD, Steyerberg EW. Cost study of metal stent placement vs single-dose brachytherapy in the palliative treatment of oesophageal cancer. British Journal of Cancer, 2004. 90(11): p. 2067-72.

Eijkemans MJC, Polinder S, Mulders AGMGJ, Laven JSE, Habbema JDF, Fauser BCJM. An individualized cost-effective treatment protocol for patients with normogonadotrophic anovulatory infertility (WHO 2). Human Reproduction. 2005. 20:2830-2837.

Heijnen EMEW, Polinder S, Macklon N, Habbema JDF, Fauser BJCM, Eijkemans MJC. Health economics of two IVF strategies: Mild ovarian stimulation in combination with single embryo transfer versus standard ovarian stimulation in combination with dual embryo transfer. Submitted.

Heijnen EMEW, Eijkemans MJC, De Klerk C, Polinder S, Beckers NG, Klinkert ER, Broekmans FJ, Passchier J, Te Velde ER, Macklon NS, Fauser BJCM. A mild strategy in IVF results in favourable outcomes in terms of term live birth, cost and patient discomfort. Submitted.