**Incidence of injuries in Norway: linking primary and secondary care data**

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**ABSTRACT**

*Aims*: Most studies of injury incidence underestimate the total burden of injury, as they do not include injuries treated in primary care. The aim of this study was to measure the total incidence of medically treated injuries in Norway. We further investigated the epidemiology of injuries treated in primary and secondary care. *Methods*: We collected individual-level data on injury diagnoses from the Norwegian Patient Registry and the national registry dataset for reimbursement of primary care providers for the period 2009-2014, and estimated the annual incidence of patients registered with an injury diagnosis in either or both of these registries. We also converted ICD-10 codes in secondary care into ICPC-2 codes to compare the types of injuries treated in primary and secondary care. *Results*: The annual incidence of medically treated injuries in Norway was 125 patients per 1000 inhabitants. 55 per cent of injured patients received treatment exclusively in primary care. We observed stable time trends over the six-year period. Incidence rates were higher in primary care for the youngest children and in middle adulthood, but were higher in secondary care for older people. Overall, injury incidence was higher for men, but women became more injury prone with age. We only observed this gender reversal in secondary care. With the exception of fractures, all injury types were predominantly treated in primary care. ***Conclusions:* A substantial proportion of injured patients in Norway are treated exclusively in primary care. The demographic profile of these patients differs from those treated in secondary care.**

**Keywords**: Injuries, incidence, primary health care, emergency medical services, data linkage, international classification of diseases, registries, epidemiology.

**Word count**: 3008

**BACKGROUND**

Injuries constitute a major public health problem, being one of the leading causes of death for young people worldwide [1]. In addition, a large number of non-fatal injuries contribute to poor health and reduced quality of life for individuals at all ages, as well as high costs to society [2-5]. Despite the high individual and societal burden of injury, measuring injury incidence is difficult due to data limitations and underlying methodological issues [6-12]. Moreover, the way health care systems are organised varies between countries, which complicates international comparisons of injury incidence.

In most studies, injury incidence is measured using mortality statistics, hospital data or emergency department data. However, this practice excludes the high volume of injuries treated by general practitioners (GPs) and other primary care providers. Although these injuries are usually less severe, they may contribute substantially to the total burden of injury [13-14]. Analyses based on mortality statistics, hospital data and emergency department data are therefore likely to underestimate the total injury burden [15-16]. In this study, we link injury data from primary and secondary care to explore the entire spectrum of medically treated injuries in Norway.

Including data from primary care to measure injury incidence is especially pertinent in Norway, where emergency care is organised as part of both secondary and primary care. While secondary care consists of state-owned hospitals and clinics, primary care is organised by more than 400 local municipalities and includes services by GPs, physiotherapists, chiropractors and other primary care providers. Local municipalities in Norway also offer *out-of-hours emergency primary health care*, consisting of municipality-run emergency departments for patients that need acute help. This organisation of emergency care means that a large proportion of injuries in Norway are likely to be treated in primary care.

Being able to link individual data from population-based health registries with a personal identification number gives the Nordic countries an advantage in providing estimates of disease incidence and prevalence. To our knowledge, no study has so far combined national individual-level data covering all injuries treated in primary and secondary care. The aim of this study was to measure the incidence of medically treated injuries in Norway by linking secondary and primary care data. We also aimed to investigate age and gender distributions as well as time trends. Finally, by mapping diagnostic codes between registries, we aimed to identify which types of injuries are predominantly treated in either primary or secondary care, and which injuries more often involve treatment in both.

**METHODS**

Data sources

The study population comprised all individuals who resided in Norway in the period 2009-2014, obtained from the National Registry. For this period, we collected individual-level data on injury diagnoses from two sources:

*Secondary care*: The Norwegian Patient Registry (NPR) is a nationwide health register that covers all inpatient, day patient and outpatient specialist health services in Norway. Diagnoses in NPR are coded according to the tenth edition of the *International Statistical Classification of Diseases and Related Health Problems* (ICD-10). In this study, we defined the following ICD-10 codes as an injury: S00-T78 (chapter XIX) and V01-Y36 (chapter XX). This case definition excludes certain early complications of trauma (T79), complications of surgical and medical care (T80-T88 and Y40-Y84), and sequelae of injuries (T90-T98 and Y85-Y89). We restricted the analyses to hospital admissions where an injury was the principal diagnosis for each contact (i.e., the first listed diagnosis).

*Primary care*: The national registry dataset for reimbursement of primary care providers (Norwegian acronym: KUHR) contains all electronic reimbursement records sent by GPs, chiropractors, physiotherapists and other primary care providers in Norway (including reimbursements for treatment at municipality-run emergency departments). Diagnoses in this register are coded according to the second edition of the *International Classification of Primary Care* (ICPC-2). We included the following ICPC-2 injury codes in this study [17]: fractures (L72-L76), sprains/strains/dislocations (L77-L81, L96), head injuries (N79-N80), eye injuries (F75-F76, F79), ear injuries (H76-H79), other superficial injuries, including laceration/cut/bite (S12-S13, S15-S19), burns/scalds (S14), poisoning (A84, A86), and other miscellaneous injuries (A80-A81, A88, B76-B77, D79-D80, N81, R87-R88, U80, X82, Y80). We omitted sequelae/late effects (A82, A85), complications (A87, A89) and injury complicating pregnancy (W75). We restricted our analyses to reimbursements from medical doctors with an injury as the principal diagnosis.

Statistical analyses

We calculated annual incidence rates (per 1000) by dividing the number of injured patients in a calendar year by the mid-year population of that year [18]. Individuals with multiple injury registrations in a particular year, either within or between registries, were counted only once. In other words, we estimated the annual incidence of injured individuals, rather than separate injury events. We present incidence rates overall and by registry, five-year age groups and gender, and across calendar years. For the analyses of time trends, rates were age-standardised (direct method) applying the Norwegian population of 2009 as the standard population [18].

For the analysis comparing types of injuries treated in primary and secondary care, we converted ICD-10 codes in NPR into ICPC-2 codes (one-to-one mapping). We made adaptations for ICD-10 codes that were not directly translatable to specific ICPC-2 codes. For instance, where gender-neutral ICD-10 codes (e.g., S30.2 “Contusion of external genital organs”) correspond to gender-specific ICPC-2 codes (i.e., X82 “Injury genital female” or Y80 “Injury male genital”), we used the patient’s gender to assign an ICPC-2 code. Furthermore, as codes from chapter XX in ICD-10 lack a counterpart in ICPC-2, we restricted this analysis to codes from chapter XIX. After conversion, we identified each unique ICPC-2 code per patient and determined whether an individual was registered with this code 1) exclusively in primary care, 2) exclusively in secondary care or 3) in both primary and secondary care within a calendar year. In this analysis, we excluded ICPC-2 code H77 (“Perforation of ear drum”), as this condition is not classified as an injury in ICD-10, but is instead converted to H72 in chapter VIII (“Diseases of the ear and mastoid process”). All contacts with identical ICPC-2 codes, either actual (KUHR) or converted (NPR), for an individual within a calendar year were classified as a single injury event. Given this assumption, for each injury type we estimated the proportion of injuries predominantly treated either in primary or secondary care, and which injuries more often were treated in both.

The Regional Committees for Medical and Health Research Ethics in Norway provided advance approval for this study (REC approval number: 2014/1945).

**RESULTS**

A total of 2,376,946 individuals were registered with an injury diagnosis in the period 2009-2014. Of these, 1,267,409 (53.3 per cent) were male and 1,109,537 (46.7 per cent) were female. These patients contributed to 8,003,748 injury registrations (mean number of registrations per patient: 3.4). A sizeable minority (38.6 per cent) of these individuals had only one injury registration during this six-year period, while the remainder (61.4 per cent) had multiple injury registrations. The majority of all patients (61.7 per cent) had injury registrations limited to one calendar year, while an additional 25.1 per cent had registrations in two separate years (either two consecutive or two intermittent years). A small proportion were registered with an injury diagnosis in three (9.1 per cent), four (3.0 per cent), five (0.9 per cent) or all six years (0.2 per cent).

Overall incidence rates and time trends

The population of injured patients in Norway consisted on average of 621,701 individuals annually between 2009 and 2014, corresponding to a crude rate of 124.7 injured patients per 1000 inhabitants. Overall, incidence rates were much higher in primary care than in secondary care, but both patient groups showed stable time trends over the observation period (Figure 1). Over half of the injured population (54.6 per cent) received treatment exclusively in primary care, while 25.5 per cent received treatment exclusively in secondary care. The remaining 19.9 per cent received treatment in both secondary and primary care within the same calendar year, either for the same injury (i.e., referrals or follow-up treatment) or for different injuries.

[insert Figure 1 here]

Injury incidence by age and gender

Figure 2 shows the annual incidence rates of injured patients treated in primary care (KUHR) and secondary care (NPR) across five-year age groups. Patients who received treatment in both primary and secondary care within the same calendar year were only included in the secondary care category. This figure thus presents the age distribution of those patients exclusively treated in primary care, in relation to all injured patients treated in secondary care (including those who also received treatment in primary care in the same year) and the total injured population.

[insert Figure 2 here]

Compared to patients receiving treatment in secondary care, incidence rates of injured patients exclusively treated in primary care were higher for the youngest children (0-9 years) and in middle adulthood (35-64 years). With advancing age, this pattern reversed, and incidence rates for treatment in secondary care formed a steep slope after 70 years. We also observed a distinct peak for adolescents in secondary care but not for treatment in primary care, where the age distribution was more uniform.

Overall, incidence rates were higher for men than for women, and this was particularly evident in the 20-39 year age range (Figure 3). With increasing age, women became more injury prone. However, this gender reversal only occurred for treatment in secondary care.

[insert Figure 3 here]

Comparing injury diagnoses in primary and secondary care

Table 1 shows the average annual number of injuries (as defined by unique ICPC-2 codes per individual) treated in primary care (actual codes) and secondary care (converted codes) according to type of injury, and their distribution between treatment levels. The most frequent injury category was other superficial injuries (34.0 per cent), followed by sprains/strains/dislocations (25.7 per cent) and fractures (20.5 per cent). Overall, the majority of injuries were registered exclusively in primary care, whereas one third of the injuries were exclusively registered in secondary care. Less than 10 per cent of injuries were registered in both primary and secondary care. However, this distribution varied considerably by injury type. The percentage exclusively registered in primary care was especially high for eye and ear injuries. Fractures represented the only injury category most often treated exclusively in secondary care. A substantial proportion of injuries due to poisoning were also registered exclusively in secondary care. The percentage of injuries treated in both primary and secondary care was highest for fractures, followed by poisoning and head injuries. Other superficial injuries were least likely to be treated in both primary and secondary care.

[insert Table 1 here]

**DISCUSSION**

To our knowledge, this nationwide register study is the first to cover injuries treated in primary and secondary care to measure the incidence of medically treated injuries in Norway. The results from this data linkage support the assertion that injury is a major public health challenge. On average, 12.5 per cent of the Norwegian population received treatment for injury per year in the period 2009-2014. We also showed that a substantial proportion of these injuries were treated in primary care. Annually, over half of the injured population received treatment exclusively in primary care. Most studies of injury incidence exclude this group of patients, leading to a substantial underestimate of the total burden of injury [13-16]. Including injuries treated in primary care has the added benefit of minimising the effect of some external factors that complicate analyses of injury incidence, including distance to nearest hospital, capacity and organisation of health services and local referral practices [9, 14, 19-20].

Our results also revealed that the demographic profile for injured patients differed between treatment levels. Compared to injuries treated in secondary care, incidence rates were higher in primary care for the youngest children and in middle adulthood, but lower for older people. A possible explanation for the high rates of paediatric injuries in primary care could be that these injuries are usually minor and do not require specialist treatment, combined with a lower threshold on the part of parents and staff of childcare centres and schools to seek medical treatment for this vulnerable group. In contrast, the high injury rates for older people in secondary care likely reflect a higher degree of severity but also more co-morbidity, highlighting a greater need for specialised treatment. Another interesting finding was that while injury incidence remained higher for men in all age groups for patients exclusively treated in primary care, incidence rates were higher for older women in secondary care. This gender reversal in secondary care can partly be attributed to treatment of hip fractures, where incidence rates increase sharply after 70 years of age, but more so for women [21-22]. Finally, injury incidence for the group exclusively treated in primary care showed no peak for adolescents and young adults, a pattern consistently found in secondary care [23]. Overall, these findings suggest that studies that restrict injury incidence to treatment in secondary care can give an incomplete and potentially misleading picture of injury epidemiology.

To our knowledge, this study is the first attempt to map injury diagnoses across classification systems in primary and secondary care. By converting ICD-10 codes in secondary care into ICPC-2 codes, we found that most injury types were predominantly treated in primary care, with the exception of fractures. Eye and ear injuries were especially likely to be treated exclusively in primary care, while fractures, poisoning and head injuries were most likely to be treated in both primary and secondary care. Superficial injuries (i.e., lacerations, bites) seldom required treatment in both primary and secondary care. These patterns likely reflect varying degrees of injury severity and need for follow-up treatment.

This study adds to a growing body of research using data linkage to assess the incidence and burden of injury [15-16, 24-28]. However, analyses in past studies have often been restricted to specific types of injury (e.g., poisoning, fractures, burns or road traffic casualties) and/or to specific age groups. The present study aimed to cover all injury categories (both intentional and unintentional) and patients of all ages. Another strength of our study is that the data were linked at the individual level, rather than by compiling aggregated data from different sources, as done for instance by Polinder et al. [15] and Haagsma et al. [24]. This design, made possible by the ability to link multiple population-based health registries with a personal identification number, enabled us to track individual patients across data sources, allowing for a more detailed analysis of individual treatment history.

This study has a number of limitations that could affect the interpretation of the results. For simplicity, we equated treatment in primary and secondary care with registrations in KUHR and NPR respectively. In reality, this distinction is not clear-cut. Whereas minor injuries in most municipalities in Norway are mainly handled by primary care providers and registered in KUHR, many of the same injuries occurring in some of the major cities are, for organisational or administrative purposes, instead registered in NPR. Our comparison between primary and secondary care may therefore have introduced information bias by misclassification of some groups of injured patients. Likewise, the results from this study will not necessarily generalise to countries where the health care system is organised differently.

In addition, there are questions as to the validity of these data, especially in primary care. KUHR is primarily an administrative register used to reimburse primary care services and has not been subject to much scientific investigation. The validity of diagnostic codes in this register is therefore largely unknown. Consequently, our estimates of injury incidence in primary care may be biased. The quality of data is also a concern in secondary care, especially as the choice of diagnostic codes has direct financial implications for the hospital. Several studies have attempted to validate diagnostic codes for fractures, with mainly positive outcomes [29-32]. However, we need more validation studies to assess the quality of register data, both in primary and secondary care.

Another limitation concerns our method of calculating incidence rates, where we counted the number of injured individuals within calendar years, rather than the total number of separate injury events. As patients suffering more than one injury in a particular year were counted only once that year, this study underestimates the total incidence of injuries. We should also note that this study only captures medically treated injuries within the public health service, as the two available registers used here lack data for injuries treated at private care facilities. As private treatment is usually covered at the patient’s own expense, these injuries are not systematically reported to official registers. We therefore have little information about the extent of injuries treated in the private sector. For the same reason, we also lack data for dental injuries, as dental health services in Norway mainly are provided by private dentists. Without an official registration system for treatment at private facilities, it is difficult to quantify the impact of these injuries on total injury rates. However, a recent study from Sweden found that about 2 per cent of children aged 8-10 years experienced at least one dental trauma during a three-year period [33].

Finally, the interpretation of linked injury data from primary and secondary care is complicated by the use of different classification systems for coding [34]. These classification systems differ in detail, as one ICPC code will typically correspond to multiple codes in the ICD taxonomy. For instance, ICPC-2 code L74 includes fractures in both hand and foot and corresponds to two separate 3-digit ICD-10 codes (S62 and S92). This discrepancy presents many challenges when interpreting linked data, for instance when trying to determine whether patients attending both primary and secondary care undergo treatment for the same or separate injuries. While dates can help clarify such cases, in the absence of more detailed information (e.g., medical records) there will always be room for error in interpretation. We therefore view this study as a first attempt to map these two classification systems, and call on future research to decipher these linked injury data in more detail.

**CONCLUSIONS**

By linking data from primary and secondary care, we found that the annual incidence of medically treated injuries in Norway was 125 patients per 1000 inhabitants. Over half of this population received treatment for injury exclusively in primary care. In addition, we found that the demographic profile differed between patients in primary and secondary care. Finally, with the exception of fractures, all injury categories were predominantly treated in primary care.

**ACKNOWLEDGEMENTS**

We thank Else Karin Grøholt for her support and helpful comments on the work reported in this manuscript, and Julie Whittle Johansen for language editing.

**DECLARATION OF CONFLICTING INTEREST**

The Authors declare that there is no conflict of interest.

**FUNDING**

This research was internally funded and received no specific grant from any funding agency in the public, commercial, or not-for-profit sectors.

**DISCLAIMER**

Data from the Norwegian Patient Register have been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Register is intended or should be inferred.

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**Table 1**: Mean annual number and percentage of injuries for patients treated in primary care (actual ICPC-2 codes) and secondary care (converted ICPC-2 codes) by injury category, 2009-2014. Note: ICPC-2 refers to the second edition of the *International Classification of Primary Care*.

|  |  |  |
| --- | --- | --- |
| **ICPC-2 injury category** | **Number of injuries** | **Percentage** |
|  |  | **Exclusively primary care** | **Exclusively secondary care** | **Both primary and secondary care** |
| **Other superficial injuries (e.g., laceration/cut/ bite)**  | **261 374** | **64.1** | **33.7** | **2.2** |
| **Sprains/strains/dislocations** | **197 434** | **68.3** | **26.6** | **5.1** |
| **Fractures**  | **157 703** | **31.3** | **47.8** | **20.9** |
| **Other miscellaneous injuries**  | **52 327** | **76.6** | **19.1** | **4.3** |
| **Head injury** | **41 140** | **63.2** | **25.1** | **11.7** |
| **Eye injury**  | **28 887** | **79.0** | **15.6** | **5.4** |
| **Burns/scalds** | **12 947** | **75.2** | **14.5** | **10.2** |
| **Poisoning** | **10 694** | **45.2** | **40.0** | **14.8** |
| **Ear injury** | **5 340** | **77.2** | **15.8** | **7.1** |
| **Total** | **767 845** | **59.8** | **32.3** | **7.9** |

**FIGURE CAPTIONS**

**Figure 1**: Annual age-standardised incidence rates (injured patients per 1000 inhabitants) in the period 2009-2014. Note: patients who received treatment in both primary and secondary care within one calendar year are included in both categories.

**Figure 2**: Mean annual incidence rates (injured patients per 1000 inhabitants) in the period 2009-2014 by age, genders combined. Note: patients who received treatment for injuries in both primary and secondary care within one calendar year are counted only under secondary care.

**Figure 3**: Mean annual incidence rates (injured patients per 1000 inhabitants) in the period 2009-2014 by age and gender. Note: patients who received treatment for injuries in both primary and secondary care within one calendar year are counted only under secondary care.

Figure 1

Figure 2

Figure 3