Total, gender- and age-specific incidence rates of upper extremity nerve injuries in Finland

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Abstract
The aim of this study was to describe the epidemiology of nerve injuries of the upper extremity in the whole population of Finland [1998–2016]. Data based on diagnosis codes were obtained from the Care Register for Health Care, including cases of median, radial, ulnar, musculocutaneous, axillary and digital nerves. Age- and gender-specific incidence rates, both crude and standardized (for the European normal population in 2011), were calculated. Our study included 13,440 patients with upper extremity nerve injury. The mean standardized annual incidence rate of any upper extremity nerve injury was 18.18 among men and 8.15 among women per 100,000 person-years over the study period. The incidence peaked among men at working age. Nerve injuries occurred most commonly in the fingers and thumb, with 5532 cases and mean standardized incidence rates per 100,000 person-years of 7.84 among men and 2.95 among women. The annual incidence did not change significantly over the study period.

Level of evidence: III

Keywords
Peripheral nerve injury, upper extremity, nerve injury, epidemiology

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Introduction
The incidence of peripheral nerve injuries (PNIs) varies between countries and studies (Asplund et al., 2009; Karsy et al., 2019). Traumatic PNIs have been studied more than other injury types. Up to 5% of patients with multiple injuries had PNIs in a trauma centre in Canada (Noble et al., 1998). Tapp et al. (2019) calculated the annual incidence rate of PNIs as 16.9 per 100,000 in the United States, and the ulnar nerve was most commonly affected with an annual crude incidence rate of 3.9 per 100,000. The nerves most frequently reported to suffer iatrogenic damage are the median, accessory and radial (Kretschmer et al., 2009).

A typical patient with a PNI is a man of working age (18–40 years old) (Karsy et al., 2018). The economic burden of the injuries is high: previous studies on PNIs have shown that injuries to the median or ulnar nerves cause the highest healthcare costs of all acute hand and wrist injuries; the majority of expenses were due to loss of work (Robinson et al., 2016). The costs may increase even further if PNIs are treated poorly.

The aim of this study was to determine the epidemiology, including standardized incidence rates, of nerve injuries of the upper extremity in the whole population of Finland from 1998 to 2016.

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Methods

The study population consisted of all the people living in Finland from 1998 to 2016. In Finland, all citizens are assigned a personal identification code at birth or immigration by the Population Register Centre. The code remains unchanged throughout the person’s lifetime. The personal identification code can be linked to other national registers, including the Care Register for Health Care, which covers both public and private hospitals in Finland.

Cases of upper extremity nerve injuries are coded according to the International Classification of Diagnoses (ICD), the ninth revision being from 1987 to 1995 and the tenth revision from 1996 onwards. Individuals diagnosed with ICD-10 groups S44, S54 and S64 were identified; their gender, age and year the diagnosis occurred for the first time was collected from 1998 to 2016. The data were obtained from specialist care registries, including both inpatient- and outpatient-based services. We excluded non-specific ICD codes from analysis: S44.5, S44.7, S44.8, S44.9, S54.3, S54.7, S54.8, S54.9, S64.7, S64.8, S64.9. We also excluded cases who had the same diagnosis before 1998, coded the same in ICD-10, or the analogous diagnosis in ICD-9 (Group 955).

The Finnish population size and population structure in age groups were obtained from Statistics Finland (https://www.tilastokeskus.fi).

Results

In total, there were 16,497 incident cases with upper extremity PNIs in Finland, from 1998 to 2016. After exclusion of 11 ICD codes, which were too non-specific, 13,440 cases with upper extremity PNIs were included. The mean standardized annual incidence rates for any PNI of the upper extremity were 18.18 [range 15.5–21.3] among men and 8.15 [range 6.3–9.6] among women, per 100,000 person-years over the time period. The number, mean crude and standardized incidence rates for each site of nerve injury stratified by gender are shown in Table 1. Annual incidence rates remained similar over the study period, with no major changes.

In the Finnish population, men were twice as likely (risk ratio men:women, RR = 2.32) to be diagnosed with any PNI of the upper extremity, as 69% (n = 9287) of the injuries occurred among men and 31% (n = 4153) among women. The mean age of patients with upper extremity PNI was 40 years: 39 years among men and 43 years among women. Figure 1 illustrates incidence rate of any PNI by gender and age.

The majority of the nerve injuries occurred at the level of the digits, followed by hand/wrist level. The more proximal the level, the rarer the injury was (Figure 2). The most common level of injury was fingers and thumbs with 5532 cases, and a mean standardized incidence rates per 100,000 person-years of 7.84 among men and 2.95 among women (Table 1).

Discussion

Previous epidemiological studies of upper extremity nerve injuries are mainly composed of patient samples from a single hospital or region. Our study evaluated nerve injuries of the upper extremity in the whole population of Finland (1998–2016), including 13,440 cases. The most commonly injured area in the upper extremity was the wrist and hand. A Swedish study also found that most PNIs occur in the wrist and hand region (Asplund et al., 2009). In our study, the most commonly damaged nerves were the digital nerves in the fingers and thumb, consisting of 5532 cases. The mean standardized annual incidence rate of injuries to the digital nerves of the fingers was 6.27 among men and 2.07 among women per 100,000 person-years.

The incidence rate of PNIs in upper extremities is likely to vary between countries and studies. Comparisons are difficult since results of some studies have not been standardized. In Sweden, the incidence rate of digital nerve injuries treated with
surgery (S64.3, S64.4 and S64.7) was 6.2 per 100,000 inhabitants yearly, and the cases consisted mostly of men (Thorsén et al., 2012).

The incidence rate of any upper extremity nerve injury in our study was highest among young working-aged men. This is similar to earlier studies (Asplund et al., 2009; Rosberg and Dahlin, 2004; Thorsén et al., 2012). In Finland, peak incidence was in the 20–29-year-old age group. Overall, our study revealed that young working-age men have a higher, two-fold risk, of sustaining an upper extremity nerve injury compared with women.

Our study also included rarer proximal upper extremity nerve injuries with 62 cases of musculocutaneous and 298 cases of axillary nerve injury. An insurance-based study of PNIs in US emergency departments estimated an annual crude incidence for axillary nerve injury at 0.2 per 100,000 and musculocutaneous nerve injury at 0.06 per 100,000 (Tapp et al., 2019). A previous single-hospital study

Table 1. Mean annual crude and age-standardized incidence rates of peripheral nerve injuries of the upper extremity per 100,000 person-years in Finland, 1998–2016.

| Injured nerve Diagnosis code (ICD-10) | Men (49,499,140 person-years) | Women (54,346,667 person-years) |
|---------------------------------------|-------------------------------|----------------------------------|
|                                       | Cases                         | Crude incidence [95% CI]         | Standardized incidence | Cases                         | Crude incidence [95% CI]         | Standardized incidence |
| Axillary nerve, S44.3                  | 195                           | 0.394 (0.281–0.507)              | 0.397                 | 103                           | 0.190 (0.110–0.270)              | 0.202                 |
| Musculocutaneous nerve, S44.4          | 43                            | 0.087 (0.034–0.140)              | 0.086                 | 19                            | 0.035 (0.001–0.069)              | 0.038                 |
| Median nerve at upper arm level, S44.1 | 120                           | 0.242 (0.154–0.331)              | 0.236                 | 49                            | 0.090 (0.035–0.145)              | 0.094                 |
| Median nerve at forearm level, S54.1   | 458                           | 0.925 (0.753–1.098)              | 0.902                 | 257                           | 0.473 (0.347–0.599)              | 0.505                 |
| Median nerve at wrist and hand level, S64.1 | 1042                        | 2.105 (1.845–2.365)              | 2.04                  | 493                           | 0.907 (0.733–1.082)              | 0.961                 |
| Ulnar nerve at upper arm level, S44.0  | 250                           | 0.505 (0.378–0.633)              | 0.494                 | 121                           | 0.223 (0.136–0.309)              | 0.237                 |
| Ulnar nerve at forearm level, S54.0    | 864                           | 1.745 (1.509–1.982)              | 1.70                  | 452                           | 0.832 (0.665–0.999)              | 0.887                 |
| Ulnar nerve at wrist and hand level, S64.0 | 818                        | 1.653 (1.422–1.883)              | 1.602                 | 375                           | 0.690 (0.538–0.842)              | 0.733                 |
| Radial nerve at upper arm level, S44.2 | 447                           | 0.903 (0.733–1.073)              | 0.902                 | 373                           | 0.686 (0.534–0.838)              | 0.724                 |
| Radial nerve at forearm level, S54.2   | 559                           | 1.129 (0.939–1.320)              | 1.091                 | 220                           | 0.405 (0.288–0.521)              | 0.433                 |
| Radial nerve at wrist and hand level, S64.2 | 451                        | 0.911 (0.740–1.082)              | 0.887                 | 199                           | 0.366 (0.255–0.477)              | 0.390                 |
| Digital nerve of thumb, S64.3          | 937                           | 1.893 (1.646–2.140)              | 1.820                 | 366                           | 0.673 (0.523–0.824)              | 0.724                 |
| Digital nerve of other fingers, S64.4  | 3103                          | 6.269 (5.820–6.720)              | 6.027                 | 1126                          | 2.072 (1.808–2.336)              | 2.225                 |

ICD: International Classification of Diagnoses; CI: Confidence intervals.

Figure 1. Incidence rates of nerve injuries of the upper extremity by gender and age.
reported six (4.9%) iatrogenic musculocutaneous nerve injuries in 122 surgically treated patients (Rasulić et al., 2017). Axillary nerve injuries may be caused by proximal humeral fractures, glenohumeral dislocation or surgery on the shoulder (Hems and Mahmood, 2012; Gupta et al., 2020; Rasulić et al., 2017). In our study, the standardized incidence of axillary nerve injury in was 0.39 among men, and 0.19 among women.

According to previous studies, acute care for median or ulnar PNIs may cost up to US$169,408 (Robinson et al., 2016). In Sweden, total costs per patient involved in working-life was €51,233 for a median nerve injury and €31,186 for ulnar nerve injury; 87% of total costs resulted from loss of productivity due to sick leave (Rosberg et al., 2005). We found no reduction in the incidence of nerve injuries from 1998 to 2016. Focusing on factors that cause nerve injuries of the upper extremity might help to prevent them. Attention should particularly be paid to occupational safety.

The strengths of our study include nationwide data obtained from a very reliable register: the Care Register for Health Care has proven to be reliable, including both inpatient- and outpatient-based services of both public and private hospitals nationwide (Sund, 2012). In Finland, the healthcare system is based on publicly funded universal healthcare. Usually, PNIs are treated in specialist care, so we assume that the vast majority of them are included in our register. On the other hand, using registry data has the risk of coding error and missing diagnoses, and the data only included patients seeking medical advice for their injury. Additionally, based on ICD-10 codes, the site, exact finger or cause of the PNI remains unknown. Exclusion of non-specific codes may have resulted in an overall underestimation of incidence. These codes included injury to multiple nerves at the shoulder, forearm, wrist and hand and to cutaneous nerves at upper arm and forearm levels.

In conclusion, between 1998 and 2016 there were 13,440 cases of nerve injury in the upper extremity in Finland. Incidence of any nerve injury was 18.18 per 100,00 person-years in men and 8.15 in women. Incidence peaked among working-aged men. The most common level of nerve injury was the hand, especially digits.

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