

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

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## **Contributorship details:**

Kirsi Wiman: PhD candidate. Designing the work, analysis, writing the article.

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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 incident 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 13,458 patients with upper extremity nerve injury. The mean standardized incidence rate of any upper extremity nerve injury was 1.18 among men and 0.05 among women per 100,000 person-years over the study period. The incidence peaked among men at working age. The most common nerve injury level was the fingers and thumb, with 5,533 cases and mean standardized incidence rates per 100,000 person-years of 0.51 among men and 0.19 among women.

**The level of evidence: IV**

## **Introduction**

Peripheral nerve injuries (PNIs) of the upper extremity cause prolonged work disability and increased healthcare costs (Bergemeister et al., 2020; Jaquet et al., 1997). PNIs can be caused by lacerating or penetrating trauma, bone fractures, traction events or ischaemia (Waldram, 2003). Iatrogenic nerve injuries are usually caused by direct damage during surgery (Kretschmer et al., 2009).

The incidence rate of PNIs varies between countries and studies (Asplund et al., 2009 ; Karsy et al., 2018). Traumatic PNIs have been studied more than other injury types. Up to 5% of patients with multiple injuries had PNIs in a trauma center in Canada (Noble et al., 1998). Tapp et al. calculated the annual incidence rate of PNIs as 16.9 per 100,000, and the most commonly affected was the ulnar nerve with an annual crude incidence rate of 3.9 per 100,000 (Tapp et al., 2019). The most commonly reported nerves with iatrogenic damage are median, accessory and radial nerves (Kretschmer et al., 2008).

A typical patient with a PNI is a man at working age (18–40-year-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 of nerve injuries of the upper extremity in the whole population of Finland from 1998 to 2016. To our best knowledge, this is the first population-based study reporting standardized incidence rates of nerve injuries of the upper extremity.

## **MATERIALS AND METHODS**

### **Study population**

The study population consisted of all the people living in Finland between 1998 and 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.

The incident 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 on. Persons 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 in- and outpatient-based services. We excluded from analysis non-specific ICD codes: 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 persons 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 (Statistics Finland).

### **Statistical analysis**

Incidences of nerve injuries in the upper extremity were counted as cases per 100,000 person-years by dividing the number of new cases in each age group by the population of that age group in Finland. The incidence numbers were calculated for each year and both genders separately. The mean incidence rates were calculated by dividing the total number of diagnoses by the sum of the population in each age group, separately for both genders. Risk ratios between genders were calculated. Standardization of the incidence rates was carried out by a straight method, using the European Standard Population 2011 as the reference (Statistics Finland). The 95% confidence intervals were calculated assuming a Poisson distribution of the cases.

## RESULTS

In total, there were 16,497 incident cases with upper extremity PNIs in Finland, from 1998 to 2016. Of those, 11 ICD codes were too non-specific and therefore not included in the study. Ultimately, 13,458 incident cases with upper extremity PNIs were included. The mean standardized incidence rates for any PNI of the upper extremity were 1.18 among men and 0.50 among women, per 100,000 person-years over the time period. Table 1. illustrates the number of all evaluated diagnoses and the mean crude and standardized incidence rates stratified by sex.

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 69.0% ( $n=9,287$ ) of the injuries occurred among men and 31.0% ( $n=4171$ ) among women. The mean age of patients with incident upper extremity PNI was 40 years: 40 years among men and 43 years among women. Figure 1. illustrates incidence rate of any PNI by gender and age. The majority of these injuries occurred at the finger level, followed by hand/wrist level. The higher the level, the rarer the injury was. Figure 2. illustrates the level of the injury in both genders and in the whole study population. The most common level of injury was fingers and thumbs with 5,533 cases, and the mean standardized incidence rates per 100,000 person-years of 0.51 among men and 0.19 among women. Figures 3. and 4. illustrate the level of nerve injury in men and women, respectively.

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.

Person-years	Men	49 499 140		Women	51 498 067	
Injured nerve, Diagnosis code (ICD-10)	Cases	Crude incidence (95% CI)	Standardized incidence	Cases	Crude incidence (95% CI)	Standardize incidence
Axillary nerve S44.3	195	0.025 (0.025-0.025)	0.024	103	0.012 (0.012-0.012)	0.012
Musculocutaneus nerve S44.4	43	0.005 (0.005-0.005)	0.005	19	0.002 (0.001-0.003)	0.002
Median nerve at upper arm level S44.1	120	0.016 (0.016-0.016)	0.015	49	0.006 (0.006-0.006)	0.006
Median nerve at forearm level S54.1	458	0.060 (0.060-0.060)	0.058	275	0.030 (0.030-0.030)	0.030
Median nerve at wrist and hand level S64.1	1042	0.138 (0.138-0.138)	0.132	493	0.060 (0.059-0.060)	0.060
Ulnar nerve at upper arm level S44.0	250	0.033 (0.033-0.033)	0.032	121	0.014 (0.014-0.014)	0.014
Ulnar nerve at forearm level S54.0	864	0.114 (0.114-0.114)	0.110	452	0.054 (0.054-0.054)	0.055
Ulnar nerve at wrist and hand level S64.0	818	0.108 (0.108-0.109)	0.104	375	0.046 (0.046-0.046)	0.046
Radial nerve at upper arm level S44.2	447	0.058 (0.058-0.058)	0.056	373	0.043 (0.043-0.043)	0.043

Radial nerve at forearm level S54.2	559	0.074 (0.074-0.074)	0.071	220	0.026 (0.026-0.026)	0.027
Radial nerve at wrist and hand level S64.2	451	0.061 (0.060-0.061)	0.058	199	0.024 (0.024-0.024)	0.025
Digital nerve of thumb S64.3	937	0.126 (0.126-0.126)	0.116	366	0.045 (0.045-0.045)	0.046
Digital nerve of other fingers S64.4	3103	0.416 (0.416-0.416)	0.400	1126	0.138 (0.138-0.138)	0.140

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Figure 1. Incidence rates of nerve injuries of the upper extremity by gender and age.

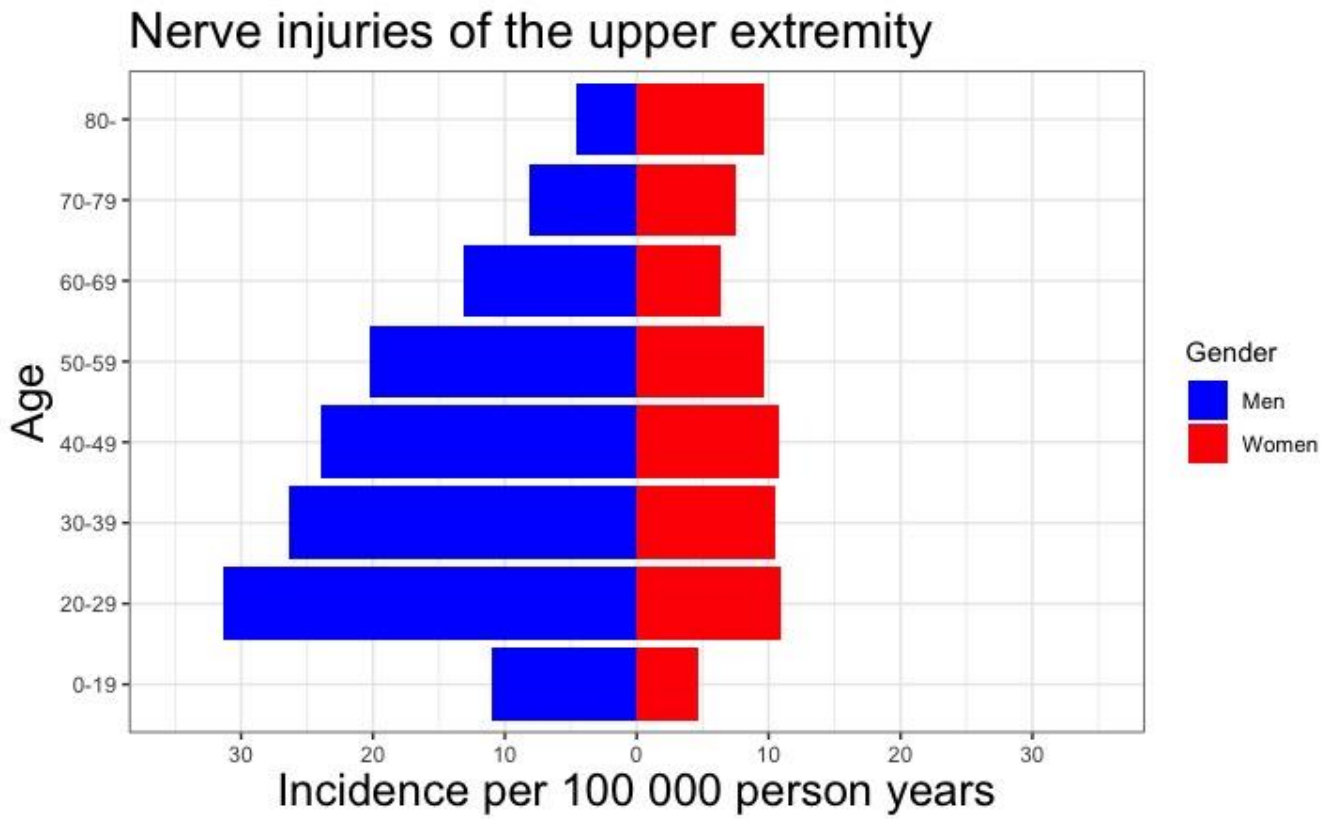




Figure 2. Level of the upper extremity nerve injuries as percentage in the whole study population.

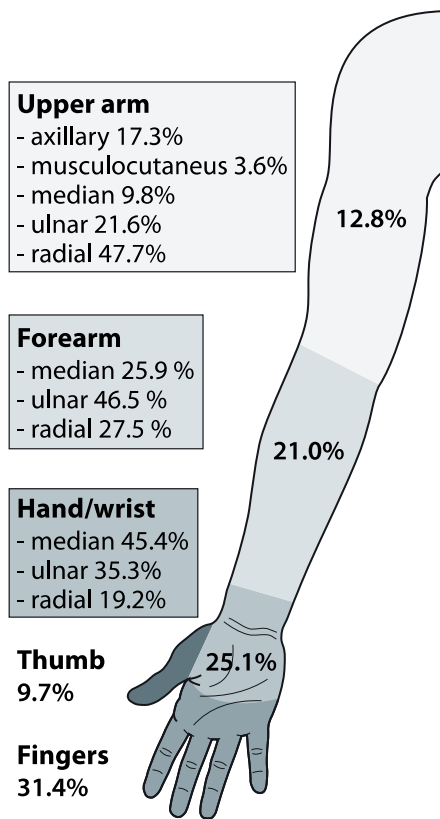


Figure 3. Level of the upper extremity nerve injuries as percentage in men (blue).

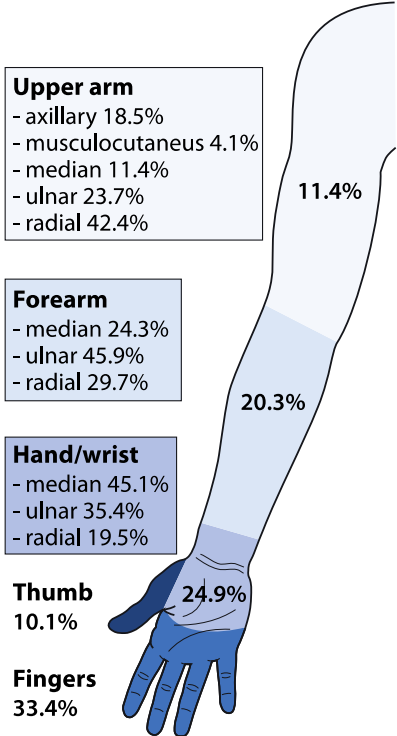
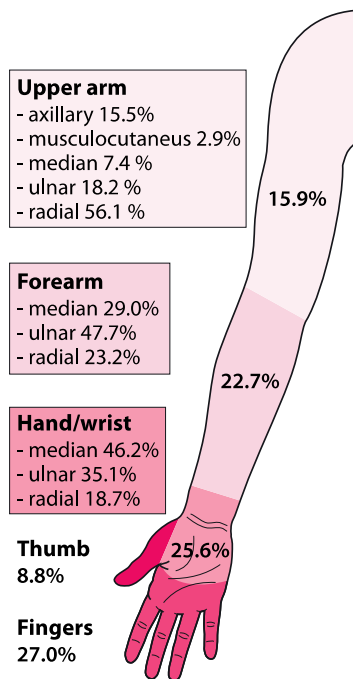


Figure 4. Level of the upper extremity nerve injuries as percentage in women (red).



## DISCUSSION

Previous epidemiological studies of upper extremity nerve injuries are mainly composed from patient samples of a single hospital or region. Our study evaluated nerve injuries of the upper extremity in the whole population of Finland (1998–2016). Our nationwide study included 13,458 upper extremity nerve injury cases, and the most common 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 nerve was the digital nerve in the fingers and thumb, consisting of 5,532 cases. The mean standardized annual incidence rate of digital nerve injuries was 0.4 among men and 0.14 among women, and for the thumb 0.12 among men and 0.05 among women per 100,000 person-years.

The incidence rate of PNIs in upper extremities varies between countries and studies. Comparisons of the studies are difficult since these studies have not standardized their results. 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; Thorsén et al., 2012; Rosberg and Dahlin, 2004). In our study, there was an incidence peak in the 20–29-year-old age group. Overall, our study revealed that young working-age men have higher a two-fold risk of getting an upper extremity nerve injury compared to women.

In comparison to men, women over 80 years of age had significantly more nerve injuries. This might be due to osteoporotic fractures, which are more common among women of this age group compared to men of the same age (Cummings and Melton, 2002). A higher number of severe fractures might lead to a higher likelihood of combined nerve injuries.

Our study also included rare upper extremity nerve injuries such as musculocutaneous and axillary nerves. In our study population, of 13,458 patients, 62 had musculocutaneous and 298 axillary nerve injuries. To the authors' knowledge, there are no previous population-based studies of incidence of musculocutaneous or axillary PNIs. 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 reported six (4.9%) iatrogenic musculocutaneous nerve injuries of 122 surgically treated patients (Rasulić et al., 2017). According to the literature, axillary nerve injuries may be caused in surgeries for shoulders or humeral fractures, or glenohumeral dislocation (Rasulić et al., 2017; Gupta et al., 2020). In our study, the standardized incidence of axillary nerve injury in was 0.024 among men, and 0.012 among women.

According to previous studies, acute care for median or ulnar PNIs may cost up to 169,408 USD (Robinson et al., 2016). In Sweden, total costs per patient involved in working-life was 51,233 euros for a median nerve injury and 31,186 euros for ulnar nerve injury; 87% of total costs resulted from loss of productivity due to sick leaves (Rosberg et al., 2005). Focusing on factors that cause nerve injuries of the upper extremity might help to prevent them. Attention should be paid to occupational safety in particular.

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.

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