Injury Epidemiology

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Hospital admissions for non-fatal drowning in Finland, 2002–2023: a nationwide population-based register study

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Abstract

Background Nationwide epidemiological data on non-fatal drowning are lacking. The purpose of this study was to provide and analyze data on incidence and time-trends of hospital inpatient admissions for drowning in Finland.

Materials and methods The Finnish Hospital Discharge Register was retrospectively searched for all inpatient hospitalizations due to unintentional and intentional drowning from January 1, 2002 to December 31, 2023 and included the entire Finnish resident population. The main outcome measure was the annual number of and crude incidence rates (n/100 000 population) of hospital admissions for drowning. The Poisson regression method was used to analyze time-trends.

Results A total of 1205 patients (mean 54.8 per year, CI_{95}: 47.4–62.2; 52.7–68.9; mean age: 40.8 years, CI_{95}: 39.2–42.3; male to female RR: 2.6) were hospitalized for drowning (1079 unintentional, 64 self-harm, 7 assault, 55 undetermined). The mean crude incidence rate of hospital admissions for drowning was 1.01 /100 000/year and decreased from 1.73 in 2002 to 0.52/ 100 000 persons in 2023. The incidence of such non-fatal drownings (0.91/100 000/year) significantly decreased during the study period (-4.9% / year; $p < 0.0001$). The age distribution showed two peaks with a first peak in children 0 to 4 years old and a second one among individuals 45 to 64 years old. The most frequent setting was a natural body of water, followed, in adults, by ice-covered bodies of water and leisure boating and, in children, by swimming pool/ bathtub. The rate ratio between non-fatal accidental drowning requiring hospitalization, and fatal drowning was exceedingly low (0.3).

Conclusions Non-fatal drownings are crucial for assessing the overall burden of drowning although, in Finland, hospital admissions for drowning have significantly declined, and fatal drownings outnumber non-fatal drownings, at least those requiring inpatient hospital care. The epidemiological profile of non-fatal drowning may substantially vary, even among high-income countries.

Keywords Epidemiology, Drowning, Non-fatal drowning, Incidence, Hospital discharge register, Finland.

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Introduction

Drowning is defined as "the process of experiencing respiratory impairment from submersion/immersion in liquid" [1]. Drowning incidents can be classified, based on their outcome, as fatal or non-fatal. Non-fatal drowning may result in morbidity, such as brain damage and permanent disability, or no morbidity [2].

Fatal drownings account each year for over 300 000 deaths worldwide [3]. The World Health Organization (WHO) provides general country-specific data on drowning mortality [4], which are used for global and multi-country surveys [5–9]. In addition, national or regional studies, in high-income countries (HIC) [10–18] and, more recently, also in low- and middle-income countries [19–24], have provided epidemiological data on fatal drownings.

Conversely, few studies have contributed national data on non-fatal drownings [3]. Most data are limited to sub-national cohorts or focus on children [25–31]. Recently, in Australia, a national report has addressed non-fatal drowning [32], and another study has compared non-fatal to fatal cases [33]. In Sweden, a nationwide study has also compared fatal and non-fatal drowning [34].

In Finland, drowning mortality rates remain among the highest among HIC [10, 35–38]. Some Finnish studies have addressed non-fatal drowning, focusing on children and on clinical aspects [39–41], but thus far, no study describes the incidence and trends of non-fatal drowning. To fill this gap, we conducted a population-based, nationwide, retrospective study of all non-fatal unintentional and intentional drownings resulting in inpatient hospital admissions in Finland from 2002 to 2023.

Materials and methods

Source of data

Patient data came from the Finnish Hospital Discharge Register (FHDR) [42], a statutory registry maintained by the Finnish Institute for Health and Welfare (FIHW) operating under the Finnish Ministry of Social Affairs and Health. The FHDR covers the entire Finnish population (2023: 5,58 million [43]). Since 1969, it has collected in-patient care-related data from all Finnish public and private health-care providers, i.e. hospitals, health-care centers, and other medical institutions (military, prisons wards) [44].

Each FHDR record contains patient data on over 60 variables including personal identification code, age and gender, admission and discharge dates, and hospital identifier [42]. Each patient's record shows the primary diagnosis with an International Classification of Diseases (ICD) code. If the primary diagnosis is an injury, a specific field must record an external cause-of-injury code (E-code)[1]. During the study period, all diagnoses were recorded by use of the ICD, 10th Revision (ICD-10) [47].

Design and setting

The present study was a population-based, nationwide, retrospective study of all patients, resident in Finland, admitted to hospitals or other health-care providers for inpatient treatment of drowning[2], in Finland, from January 1, 2002 to December 31, 2023. The term "hospital inpatient admission" and "inpatient hospitalization" are referred to here as "hospital admission" and "hospitalization".

The FHDR was searched for all inpatient hospitalizations due to drowning as follow: a) the primary diagnosis had an ICD-10 nature-of-injury code (I-code) in the range "S00-T98" (Chapter XIX "*Injury, Poisoning and Certain Other Consequences of External Causes*") and b) the external cause had an ICD-10 E-code for drowning (unintentional: V90, V92, W65-74; self-harm: X71; assault: X92; undetermined intent: Y21) (Table 1; Supplementary files 1,2)[3].

The main outcome variable was the annual number of hospital admission with an E-code for drowning (here referred to as "non-fatal drowning"). For each patient, only the first admission was selected, i.e. one patient was counted only once, even in cases of re-admission. Hospital admissions followed by in-hospital deaths were included in the study[4].

Table 1 World health organization (WHO), ICD-10 E-codes for unintentional and intentional drowning used in this study [47, 48]. Terms in bold font indicate the main intents of drowning

Unintentional	**V90, V92, W65-W74**
Boating-related	*V90, V92*
Other unintentional	*W65-W74*
Self-Harm	**X71**
Assault	**X92**
Undetermined	**Y21**

[1] The WHO recommends classifying injuries such as drowning, using both the ICD nature-of-injury code (I-code) and the external-cause code (E-code). The I-code identifies the nature of injury (e.g. drowning), whereas E-codes describe the circumstances and settings leading to death (boating, natural bodies of water, swimming pool) [36, 45, 46].

[2] For briefness, "admissions to hospital or other health care provider" are referred to here as "admissions to hospital".

[3] The FHDR combines the Finnish version of the WHO ICD-10 [48] 3-character categories for drowning in the range W65-75 as follows: W68 "Drowning and submersion in swimming-pool and bathtub" (WHO ICD-10: W65-W68); W69 "Drowning and submersion in natural water" (W69-W70); W74"Other and unspecified drowning and submersion" (W73, W74). The Finnish version of the ICD-10 has an additional code (W71) for "Drowning and submersion as a result of falling through ice-covered bodies of water".

[4] Hospital admissions followed by in-hospital deaths could be identified by a specific discharge code only from 2002 to 2017; after 2017, the FHDR does not provide specific discharge information for in-hospital deaths.

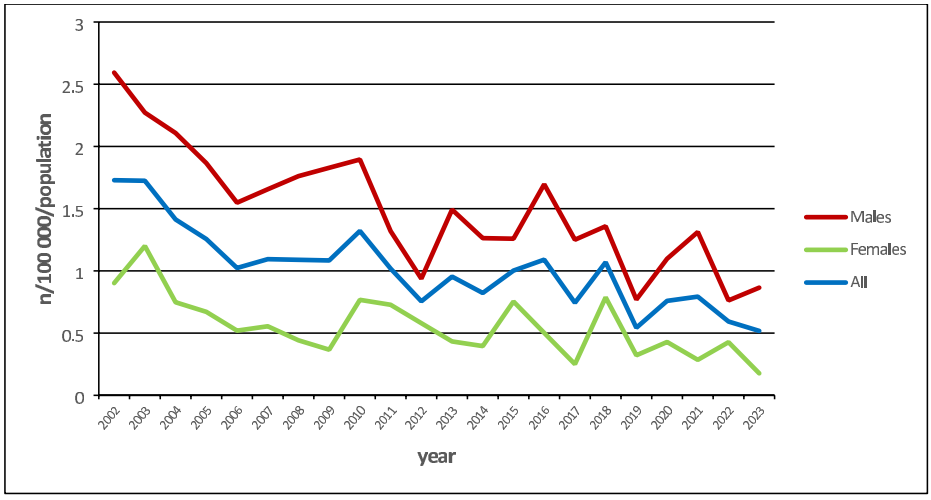

Fig. 1 Hospital admissions for non-fatal drowning, Finland, 2002–2017: crude incidence rate and time-trends, by gender

Non-fatal drownings requiring hospitalization, were analyzed by patients' gender and age, month of occurrence, manner of death (unintentional, self-harm, assault, undetermined), and by type of health-care providers. Unintentional drownings, the primary focus of the present study, were analyzed also by circumstances and settings.

The *Official Statistics of Finland* [43], a statutory, computer-based population register provided annual Finnish population data on 31 December to compute crude overall and age-specific incidence rates. During the study period the Finnish population increased from 5,200,598 (2002) to 5,603,851 (2023). The share of the Finnish population aged 50 or older increased from 35.4% in 2002 to 41.8% in 2023.

The Finnish *Cause-of-Death Register* (CODR) [49],[5] maintained by Statistics Finland (SF), provided mortality data to determine the non-fatal to fatal rate ratio (RR) of drowning, by intent (accidental, self-harm, assault, undetermined).

Statistical analysis

The Poisson regression adjusted by relevant risk population size was used to analyze time-trends. The t- and z-test were used for comparisons of age and proportions. All analyses were performed using R program version 4.4.2 [51].

Ethical approval

In Finland, register studies with no identifiable individual patients and with no contact with the patients require no ethical committee approval. Informed consent was unnecessary, because all patients were anonymized.

Results

General

Between 2002 and 2023, a total of 1205 patients (72.2% male) were admitted to hospital for non-fatal drowning. Such non-fatal drownings ranged from a high of 90 per year in 2002 and 2003 to a low of 29 in 2023 (mean: 54.8/year; CI_{95}: 47.4–62.2). The mean annual incidence rate of hospital admission for overall non-fatal drownings was 1.02 per 100 000 population (male: 1.50; female: 0.56).

Among the 1205 patients hospitalized, 499 were treated at university hospitals (Helsinki, Tampere, Turku, Oulu, and Kuopio), 587 in central and district hospitals, 110 in health-care centers, 8 in private health-care providers, and one in a military ward.

The mean patient age at admission was 40.8 (years) (range: 0–98; CI_{95}: 39.2–42.3). Male patients were older (mean 42.5 years; CI_{95}: 40.7–44.2) than female patients (36.3 years; CI_{95}: 33.2–39.4) (p-value: 0.0006). The age distribution was bimodal, with a first mode in children aged 0 to 4 years ($n = 188$) and a second one in 45- to 64-year-olds ($n = 336$). Mean age figures rose from 32.1 years in 2002, to 38.8, in 2023 ($p = 0.229$).

The incidence rates of hospital admissions during the study period significantly declined (– 4.2%/year; CL_{95}: –5.1; –3.3; $p < 0.001$), a similar downward trend occurring both in male (– 4.2%/year; CL_{95}: – 5.2; – 3.2; $p < 0.001$) and female patients (– 4.4%/year; CL_{95}: –6.0; –2.7; $p < 0.001$) (Fig. 1). The incidence rate was 1.73 per 100 000 population in 2002, and 0.52 per 100 000, in 2023.

Intent of the injury (unintentional vs. intentional)

Of the 1205 hospital admissions for non-fatal drownings, 1079 (89.5%) were unintentional, 64 (5.3%) suicide

[5] The CODR cover all Finnish residents. Causes of death are reported in all cases of injury deaths, including drowning, almost always by forensic physicians conducting medico-legal autopsies [50].

Table 2 Hospital admissions for non-fatal drowning among 1205 patients in Finland, 2002–2023: crude incidence rates, mean age, and male-to-female rate ratio (M: F RR). Terms in bold font indicate the main intents of drowning

	n	Crude incidence rate	Mean age both genders		M: F RR
		n/100 000/year	Years	(CI_{95})	
Unintentional	1079	0.91	40.0	(38.4–41.6)	2.8
Boating-related	*134*	*0.11*	*45.3*	*(41.6–48.9)*	*4.6*
Other unintentional	*945*	*0.79*	*39.2*	*(37.5–41.0)*	*2.6*
Self-harm	64	0.05	52.2	(47.2–57.3)	1.3
Assault	7	< 0.01	26.1	(14.7–37.5)	6.0
Undetermined	55	0.05	44.5	(37.9–51.0)	1.6
Total	**1205**	**1.01**	**40.8**	**(39.2–42.3)**	**2.6**

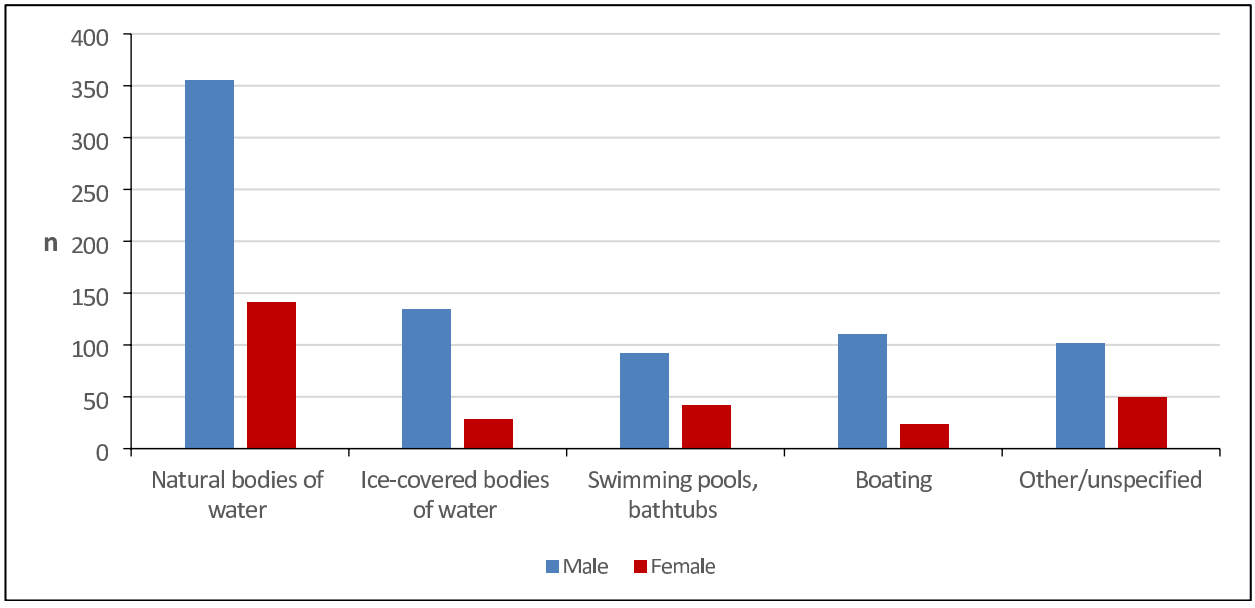

Fig. 2 Hospital admissions for non-fatal unintentional drowning ($n = 1079$), Finland, 2002–2023: distribution by circumstances/settings and gender

attempts, 7 assaults (0.6%), and 55 (4.6%) remained of undetermined intent (Table 2). The patients hospitalized for self-harm incidents were significantly older than those hospitalized for unintentional drowning. Conversely victims of assault were significantly younger than patients hospitalized for unintentional and self-harm incidents.

Unintentional drowning

Setting, age, gender

Among 1079 unintentional non-fatal drownings requiring hospitalization, 134 (12.4%) were boating-related and 945 (87.6%) were other unintentional drownings. Among the latter, 496 (52.5%) occurred in natural bodies of water (e.g. sea, lake, river), 163 (17.2%) were due to falling through ice-covered bodies of water, and 134 (14.2%) occurred in swimming pools or bathtubs. The site of drowning was "other or unspecified" in 152 cases (16.1%) (Fig. 2).

In boating-related non-fatal drownings, 110 were male victims (82.1%) and 24 female (17.9%) (M: F RR = 4.6) and corresponding values for other non-fatal drownings were 684 (72.4%) and 261 (27.6%) (M: F RR = 2.6). Mean patient age was higher for males, both in boating-related drowning (male: 48.4 years, CI_{95}: 44.7–52.0; female: 31.0 years, CI_{95} 21.2–40.8; $p = 0.0019$) and in non-boating related drownings (male: 42.1 years, CI_{95} 39.1–43.2; female: 34.1 years, CI_{95} 30.6–37.7; $p < 0.001$).

The age distribution in unintentional non-fatal drowning requiring hospitalization, has two peaks, with the first peak in children 0 to 4 years old, and the second in 45- to 64-year-olds. Children of that age-range accounted for 17.1% and those 0 to 14 years old for 27.0% of the cases. When considering age-specific incidence rates, 0 to 4-years old showed a prominent peak (Fig. 3).

In children less than 15-year olds ($n = 291$), the leading setting was a natural body of water (45.7%), followed by swimming-pool and bathtub (33.7%), other/unspecified site (15.5%), boating (3.4%), and fall through ice-covered bodies of water (1.7%). In people aged 15 or more ($n = 788$), the leading setting was a natural body of water

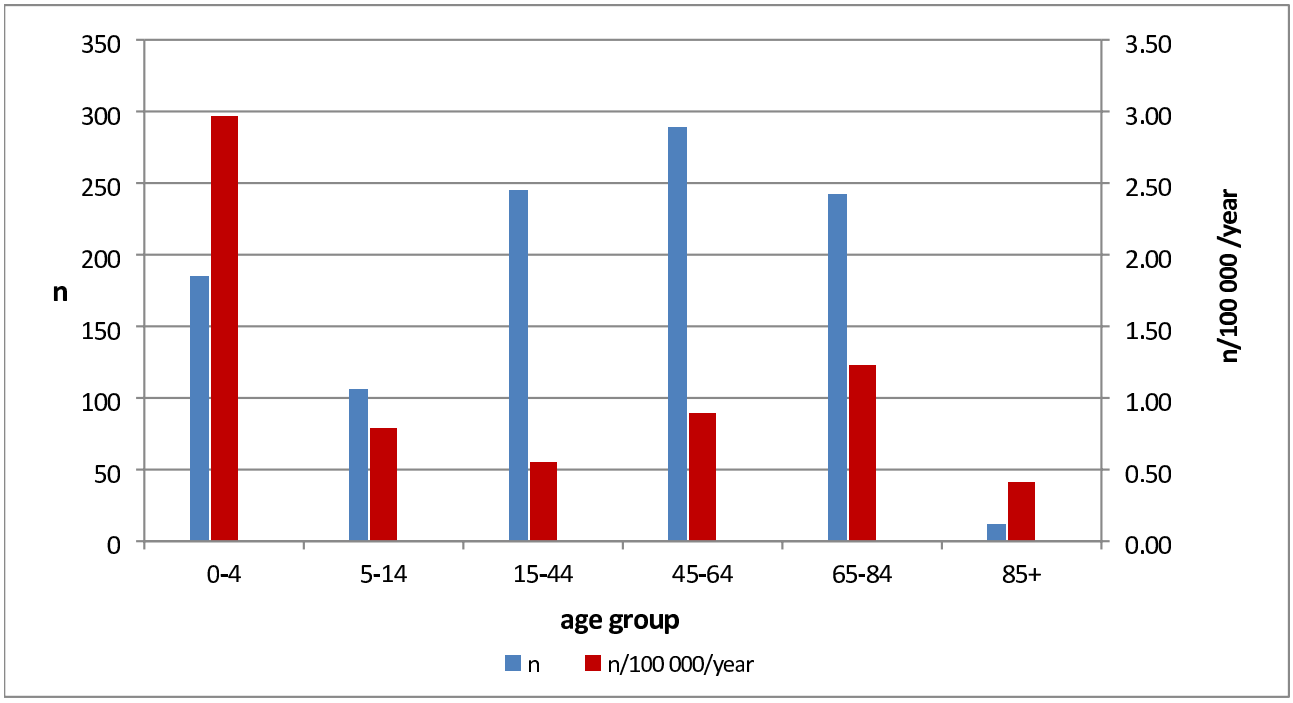

Fig. 3 Hospital admissions for non-fatal unintentional drowning ($n = 1079$), Finland, 2002–2023: distribution by age group (frequency: left y-axis, blue bar; incidence: right y-axis, red bar)

Table 3 Hospital admissions for non-fatal unintentional drowning ($n = 1079$), Finland, 2002–2023: frequency, by age groups and by circumstances/settings

	Natural bodies of water	Ice-covered bodies of water	Swimming-pool, bathtub	Boating-related	Other/unspecified
0–4	88	4	58	2	33
5–14	45	1	40	8	12
15–44	105	37	17	50	36
45–64	138	53	9	48	41
65–84	115	67	6	25	29
85+	5	1	4	1	1
All ages	496	163	134	134	152

(46.1%), followed by fall through ice (20.1%), boating (15.7%), other/unspecified site (13.6%), and swimming-pool and bathtub (4.6%) (Table 3).

The settings varied markedly among age groups, especially when considering age-specific incidence rates (Fig. 4, Supplementary file 3).

Monthly distribution

Hospital admissions for unintentional non-fatal drownings occurred mostly from April to August (67.9% of all unintentional drowning), with a peak in July (20.8%). In contrast, self-harm by drowning showed a somehow more even distribution, with a peak in November (17.2%) (Fig. 5).

Time-trends

The incidence rates of unintentional non-fatal drowning requiring hospitalization decreased significantly (–4.9%/year; CL_{95} –6.3, –3.5; $p < 0.0001$). A significant decline occurred for all main age groups (0–14 years: –4.3%/year; CL_{95}: –6.1, –2.5; $p < 0.0001$; 15–44 years: –7.0%/year; CL_{95}: –8.9, –5.0; $p < 0.0001$; 45+ years: –3.6%; CL_{95}: –4.9, –2.3; $p = 0.004$) (Fig. 6).

The age distribution changed during the study period. At the beginning of the study period, a peak appeared among 15- to 44-year-olds, whereas at the end, most non-fatal drowning were among 65- to 84-year-olds and also 45- to 64-year-olds exceeded 15- to 44-year-olds (Fig. 7). When considering age-specific incidence rates, however, the peak was among 0- to 4-year-olds at both the beginning of the study period but at its end the age-specific rates did not show any clear peak, although a marked decrease was observed in this age group (Supplementary file 4).

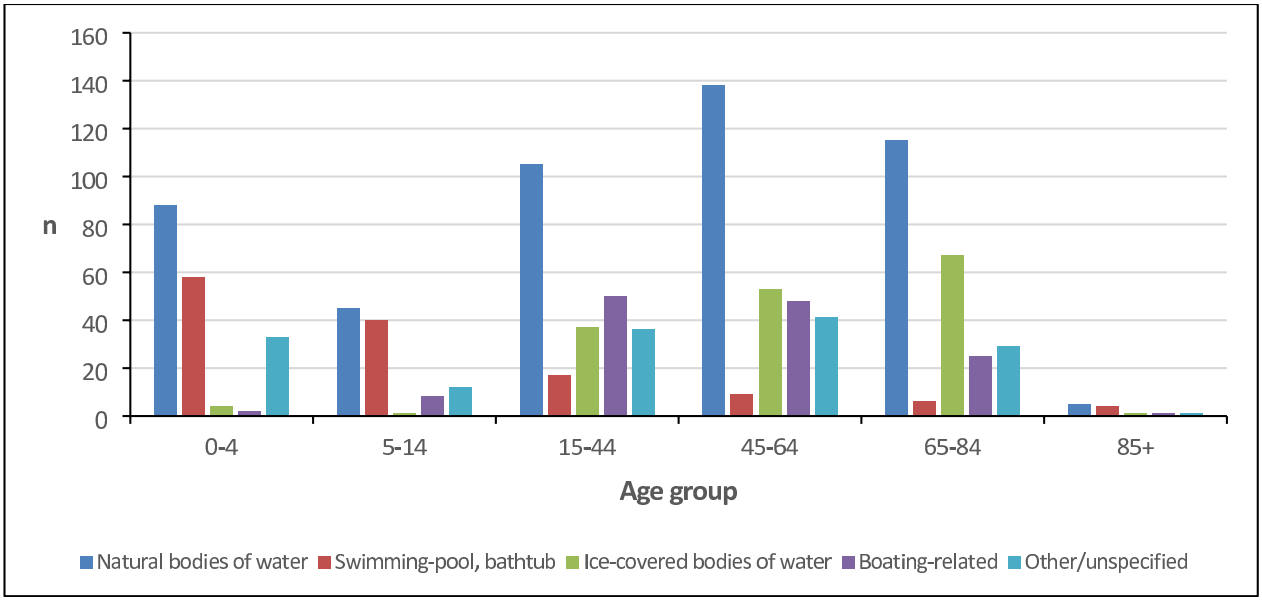

Fig. 4 Hospital admissions for non-fatal unintentional drowning, Finland, 2002–2023: frequency, by age groups and by circumstances/settings

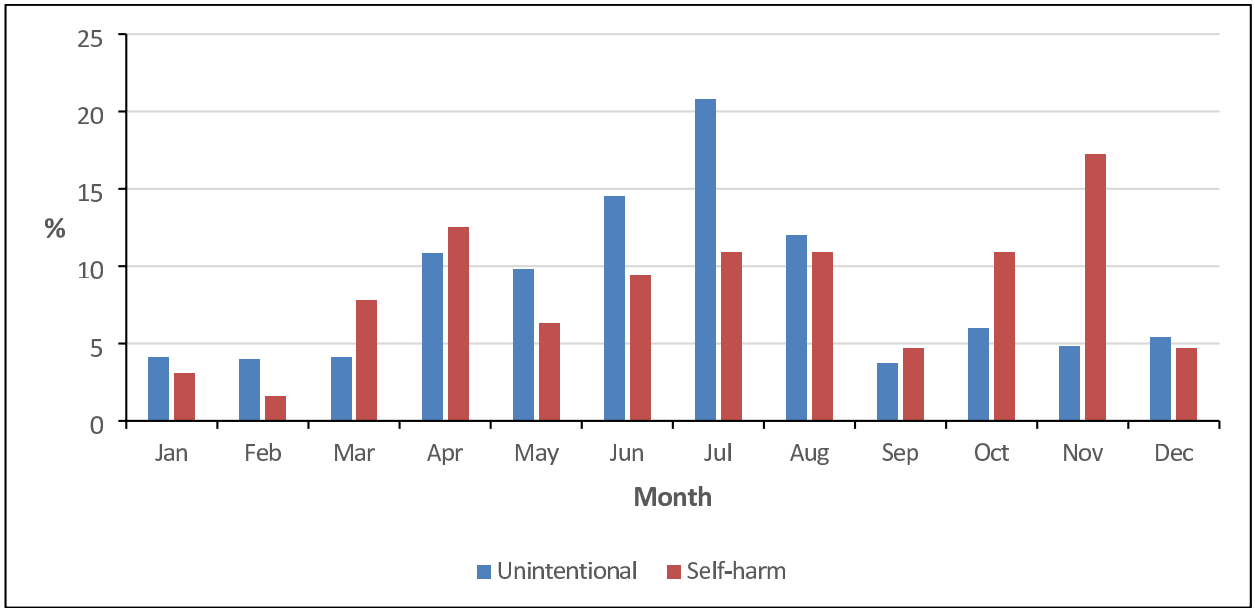

Fig. 5 Hospital admissions for non-fatal unintentional drownings ($n = 1079$) and self-harm by drowning ($n = 64$), Finland, 2002–2023: relative monthly distribution

In-hospital mortality

During the period 2002–2017, of the 872 patients hospitalized for unintentional drowning 75 (8.6%) died in hospital. These 75 in-hospital deaths represent 1.9% of all the 3882 fatal unintentional drownings that occurred in Finland during the survey period [39]. Among the 230 children less than 15 years old, 12 (5.2%) died in hospital, and among those 642 aged 15 or older, 63 (9.8%) ($p = 0.046$). From 2018 to 2023, the hospital discharge register did not allow reliable identification of hospitalized patients who died in hospital.

Fatal to non-fatal unintentional drowning ratios

During the study period, the rate ratio (RR) of fatal ($n = 4882$) to non-fatal ($n = 1205$) overall drowning was 4.1 and that of unintentional drowning ($n = 3583$ and $n = 1079$, respectively) was 3.3.

Discussion

This is the first nationwide, population-based analysis of non-fatal drownings performed in Finland. This study focused on drowning requiring hospitalization, namely inpatient care. Between 2002 and 2023, the number of

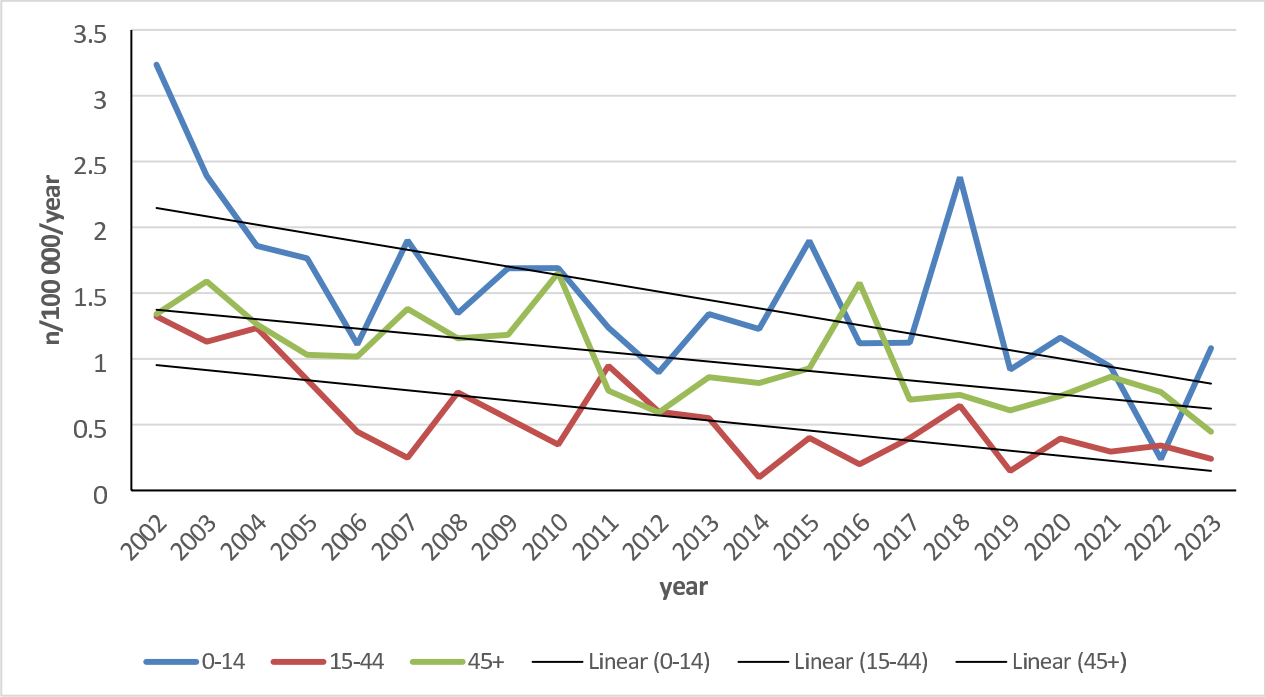

Fig. 6 Hospital admission for non-fatal unintentional drownings, Finland, 2002–2023: crude incidence rates and linear time-trends, by main age groups (0–14 years, 15–44 years, ≥ 45 years)

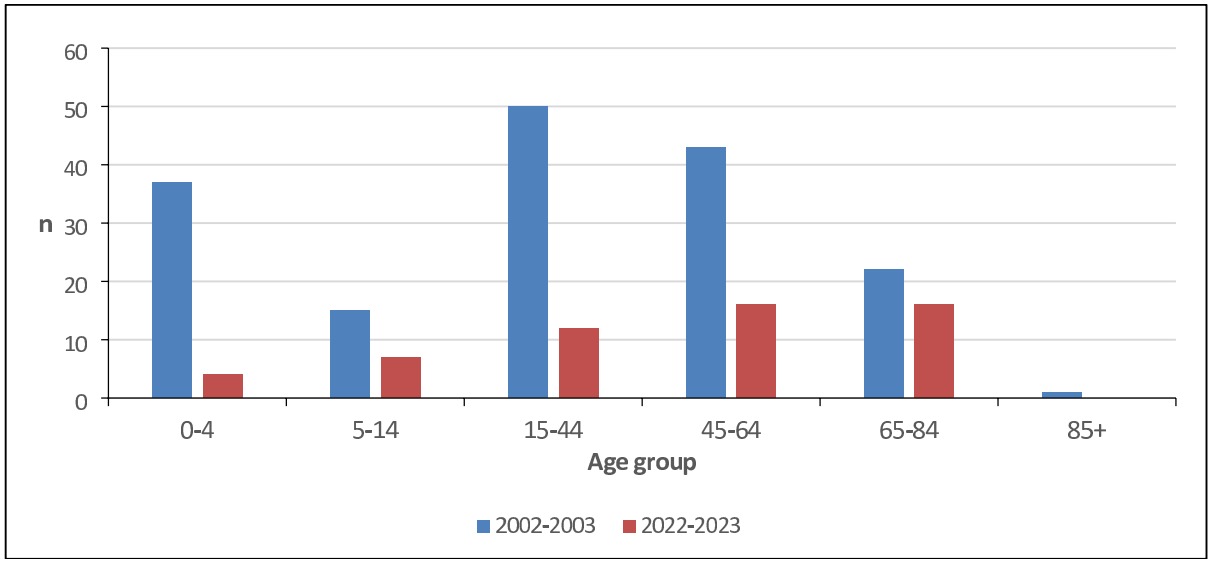

Fig. 7 Hospital admissions for non-fatal unintentional drowning, Finland: age distribution at the beginning (2002–2003) and end of the study period (2022–2023)

hospital admissions for non-fatal drowning was 1205 (89.5% unintentional, 5.3% self-harm, 0.6% assault, 4.6% undetermined). During the same period there were 4882 fatal drownings (73.4% unintentional, 19.4% suicide, 0.3% homicide, 6.9% undetermined) [49].

The annual crude incidence rate of such non-fatal drowning was, 1.014 per 100 000 population. This figure combined with SF data on fatal drowning [49], produces a total (fatal and non-fatal) average drowning incidence of 5.11/100 000 per year. During the study period, the incidence of hospital admissions declined significantly (−4.2%/year) from a high of 1.73, in 2002, to a low of 0.52 per 100 000 population, in 2023.

This decline, observable across all age groups, was more apparent among 15- to 44-year-olds. The Finnish population's aging and the less pronounced decline in

the number of the elderly may explain, at least in part, the increase in mean patient age and the shift of the most affected age-group from 15 to 44 years old to older than 65.

The decline in hospitalization for non-fatal drowning challenges the hypothesis that improved hospital care has, during the past decades, resulted in declining mortality rates [10]. Several factors may account for the simultaneous decline in fatal and non-fatal drownings: preventive measures, public awareness of risks, swimming education, and decreased exposure to aquatic settings. However, in addition to an actual decline of drowning incidents, changes in hospital admission policies and increased pre-hospital and outpatient clinical management may, especially in less severe cases, account for the decline in hospital admissions.

Inclusion of non-fatal self-harm and assault-related drowning allowed us to estimate the overall incidence of non-fatal drowning requiring hospitalization. However, hospital admission for accidental drowning remained the primary focus of the present study. Discussion on demographic, temporal, and policy-relevant characteristics of intentional drownings goes beyond the purposes of the present study.

As to hospital admissions for non-fatal unintentional drowning, males, especially adult, were over-represented (nearly 75%), and the age distribution showed two peaks of incidence one in children 0 to 4-years old and the second in 45 to 64-year olds. The high prevalence among adult males can be explained by exposure to aquatic environments associated to higher risk-taking behaviors [52, 53], including alcohol consumption [54].

The circumstances differed among age-groups. In children less than 15-years, the most common setting was a natural body of water (45.7%) and swimming-pool/bathtub (33.7%) whereas in patients aged ≥ 15 years, natural water (46.1%), falling through ice (20.1%) and boating (15.7%) were rather frequent, contrarily to swimming-pools/bathtubs (4.6%). The code "others or undetermined" (16.1%) includes less common sites of drowning (garden ponds, plastic tub, water well) and cases where sites remain unknown because no information was available at hospital admission or information was not exploited for assigning an ICD code. Although care of the injured is the main priority, medical personnel should value the relevance, for prevention of E-coding sites of drowning incidents.

The settings of non-fatal unintentional drowning, can be appreciated, considering Finland's geography, with its extended coastlines and inland waters (10% of the country surface; 168 000 lakes with a surface ≥ 500 m^2 [55]), a cold climate, and sustained aquatic activities (> 1 000 000 boats, of which > 200 000 are registered motorboat and > 14000 registered sailing boat; > 400 000 summer cottages [56, 57].

In general, the incidence is higher in summer when aquatic activities such as open-air swimming in natural waters and leisure boating are common, also due work- and school holidays and people moving to summer cottages. In addition, Finland's cold climate explains the high incidence on ice-covered bodies of water, especially in late spring, when ice is melting, and many engage in leisure activities on ice (walking, skiing, fishing).

In addition to the profile of fatal drowning, the profile of non-fatal unintentional drowning in Finland can assist in deciding upon general actions to prevent drowning. General measures to reduce drowning in natural bodies of water are necessary across all age-groups. Moreover, in adults, specific actions should focus on preventing falls through ice-covered bodies of water and risks associated with leisure boating. For children, drowning prevention should take note of unattended swimming pools and bathtubs; although fatal drownings in pools and bathtubs are in Finland relatively uncommon, partly due to the limited number of residential swimming pools and bathtub and the short open-air swimming season [10], one-third of non-fatal child drownings still occur in these settings.

Safety measures for children should emphasize the importance of close supervision, parental education, swimming-pool fencing, use of life jacket in aquatic settings, and swimming education [58]. Adults that engage alone in swimming or other aquatic activities in less supervised environments are at risk, as well. A survey in southern Finland, the most densely populated Finnish region, demonstrated that nearly 75% of fatal drownings are unwitnessed [59]. Medical fitness to engage in aquatic activities should be considered across all age-groups, as pre-existing medical conditions (cardiovascular diseases, epilepsy, autism) predispose to drowning [60–62]. Alcohol use in aquatic settings is also a major risk factor in adult fatal drowning in Finland [10, 37], but blood alcohol is not routinely measured at hospital admission. Tourists and residents who are members of other cultures represent a risk group for drowning [63, 64], but we could not address this issue, because the FHDR lacks specific identifiers for non-native residents and non-residents were excluded from the study. Secondary prevention with efficient search and rescue operations, on-site reanimation, and rapid transfer to medical facilities are all crucial for all age groups to reduce drowning morbidity and mortality.

Very limited epidemiological data exist on non-fatal drowning [3]. The lack of suitable databases and clear terminology [33] challenges consistent data collection. A working group proposed a categorization according to which a drowning incident with some degree of

respiratory impairment is always a non-fatal drowning regardless of the morbidity [2]. This broadens the concept of non-fatal drowning to include self-reported incidents and cases where only pre-hospital care is provided, for example, on-site by paramedics, at a primary health care center, or at an emergency department (ED). Therefore, ED databases [27, 65, 66], drowning registries [67], rescue organization records [68–71], and questionnaire-based surveys [20, 72, 73] all are among the data sources for non-fatal drowning that may be linked, in order to provide data across the continuum of care [29, 69].

Even considering only Hospital Discharge registers, the different coverage and quality of data, inclusion criteria and categorizations and coding practices can prevent any reliable comparative study. Some similarities and differences are evident when comparing the present survey with a recent one from Australia [32]. Both studies for instance include only non-fatal drowning requiring inpatient hospitalization and recorded as primary diagnosis and count each patient only once to avoid double counting due to possible re-admissions. However, the present study included and examined separately all ICD-10 E-coded drownings (V90, V92, W65-W74, X71, X92, Y21), whereas the Australian study involved only unintentional, non-boating–related drowning (W65-7W4). Additionally, drowning categories in the range W65-74 are combined differently in the two countries (i.e. drowning in a swimming pool and bathtub are grouped under a single code in Finland [48]). Moreover, contrarily to the Australian study, our study included patients who died in hospital and excluded non-residents.

With these restraints in mind, we can compare some Finnish figures on hospital admissions for drownings with those from Australia [32], limited to non-boating-related unintentional drownings (W65-W74). The Finnish annual incidence rate (0.79/100 000) was lower than was the incidence in Australia (2.36) as was also the age-specific incidence rate in those aged from 0 to 4 year (3.0 vs. 15.3/100 000). The time-trends of non-fatal drowning diverged, a significant decline being observable in Finland opposed to an upward trend in Australia. The Australian survey [32] shows also a higher proportion of children 0 to 4 years old (41.9% vs. 17.1%%). In this age group, the most common setting was, in Australia, swimming pool/bathtub (71.8% of unintentional non-fatal drownings vs. 31.3%) whereas it was, in Finland, most commonly a natural body of water (47.6% vs. 5.3%). Non-fatal drownings coded as "other/unspecified" were less common in Finland (17.8% vs. 30.4%).

A Swedish nationwide study [34] has reported, 2003 to 2017, an incidence (2.4/100 000) of non-fatal drowning that is more than double fold compared to the incidence of hospital admissions for non-fatal drowning that we have observed in the present study (1.01/100 000). Both the Finnish study and the Swedish one included overall non-fatal drowning, regardless of intent (accidental, self-harm, assault, undetermined). However, the Swedish study [34] included not only data of inpatient hospital admissions, as it was the case in our study, but also outpatient care visits. Considering that, in Sweden, outpatient care visits represent approximately 46% of non-fatal drownings, it is reasonable to infer that Finland and Sweden may have comparable incidence of non-fatal drowning. Finally, even considering the different dataset, it is worth noting that, in both these neighboring Nordic countries, the incidence of non-fatal drowning declined, contrarily to the upward trend that has been reported for non-fatal accidental drowning in Australia [32, 74].

This study did not aim to compare the profile of non-fatal drownings with that of fatal drownings. However, some preliminary considerations are possible. In Finland, the non-fatal-to-fatal unintentional drowning rate ratio (0.3) is very low compared to that of Australia (2.7), Sweden (1.5), and other countries [33, 34]. Even considering underestimation of non-fatal drownings (see "strengths and limitations"), fatal drownings in Finland likely remain more frequent than non-fatal ones.

Strengths and limitations

Among its strengths, this study's FHDR database covers the entire Finnish population, with data collected from all public and private hospitals and other health-care providers. The FHDR therefore provides true population figures and incidences of non-fatal drownings and avoids issues in coverage or representativeness that arise with traditional sampling- or cohort-based estimates [44]. The quality of the FHDR has been validated in several studies [75]. The coverage and accuracy of injury diagnosis are higher than 95% [76]. Additional strengths comprise the selection of all E-coded drownings (accident, self-harm, assault, undetermined intent), with no implemented changes in ICD-coding or registry practices during the study period.

A general limitation of studies based on Hospital Discharge registers is the difficulty of capturing all patients who qualify for a given diagnosis. The main sources of under-estimation in the present study are:

a. drowning incidents with no E-codes. According to ICD-10 guidelines, whenever an injury code (S00-T98) is assigned, an E-code (V01-Y98) that describes settings and circumstances leading to the injury must be provided [45]. However, this double coding frame recommendation, crucial for injury surveillance and prevention, is not implemented in many countries [46]. In 2004, the FHDR included an E-code in 87.2% of overall injuries [77], and in the present study E-codes were assigned in 96.1% of drownings.

b. drowning with an E-code other than for drowning. Categorization of drownings with an E-code other than for drowning (land-traffic accidents, flood) is a well-known issue also when assessing the burden of fatal drowning [3, 36, 46].
c. omission of secondary diagnosis of drowning. Relying only on the primary diagnosis is less inclusive and may underestimate non-drowning episodes.
d. exclusion of drowning for which the victim is treated as an outpatient, meaning treated on site, within primary health care, or in an ED. The FHDR has a section on outpatient visits in specialized health care such as ED, but this was excluded because of high E-code under-reporting (2017: > 25%) (unpublished data) and because late hospitalization of outpatients may generate double-counting issues. During the period 2019–2023 between 33 and 57 outpatient admissions in specialized health care were recorded in this section. A register of outpatient visits in primary health-care centers exists in Finland, but cases are coded with either the ICD-10 or ICPC-2 (International Classification of Primary Care) [78].
e. individuals experiencing a non-fatal drowning event but not seeking or receiving medical care.

A further issue is the inclusion of each patient's first admission. Including only first admissions prevents double counting of the same patient upon re-admissions for the same episode. On the other hand, some cases may remain uncounted if the patient is hospitalized for two separate drowning incidents. However, the possibility of one patient's sustaining two or more drowning incidents over the study period is very low, and eventually would have a negligible impact on study results.

As a final point, the present study does not provide data on the severity of the injury sustained, the length of stay in hospital after admission, the nature of hospital treatments, and the outcome and long-term effects for the patients. Clearly, without such information no estimation of the burden of non-fatal drowning requiring hospital admission is possible.

Conclusion

Non-fatal drowning incidents are crucial for assessing the overall burden of drowning, although in Finland, hospital inpatient admissions for drowning have significantly declined, and fatal drownings outnumber these non-fatal drownings. The FHDR is a primary data source of non-fatal drownings, but there still exists some area for improvement in data collection by reducing E-code under-reporting, capturing drowning incidents recorded as a secondary diagnosis, and including victims treated as out-patients, as well as alcohol-related incidents.

The circumstances and settings unintentional drowning requiring hospital treatment, show age-specific differences which have implications for prevention. Whereas natural bodies of water represent a target for prevention across all age groups, in adults, ice-covered bodies of water and boating activities and, in children, swimming pools and bathtubs, require specific prevention measures.

Future research should compare the epidemiological profile of fatal and non-fatal drownings and explore how prevention and improved health care shape the trends in out-patient care, hospitalization, morbidity, and in-hospital mortality. Moreover, further studies should investigate clinical aspects of drowning, including victims' pre-existing medical conditions, long-term outcome and subgroups with morbidities, as well as length of hospital stay and care cost.

Abbreviations

CODR	Cause-of-Death Register
ED	Emergency Department
E-code	External cause-of-death code
FHDR	Finnish Hospital Discharge Register
HIC	High income countries
ICD	International Classification of Diseases
I-code	Nature-of-injury code
FIHW	Finnish Institute for Health and Welfare
RR	Rate ratio
SF	Statistics Finland
WHO	World Health Organization

Supplementary Information

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Supplementary Material 1

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Author contributions

P.L. participated in the conception and design of the study, acquisition and analysis of the data, interpretation of data, drafting and revising the manuscript. K.H. participated in the conception and design of the study, acquisition and analysis of the data, interpretation of data and revising the manuscript draft. P.L. and K.H. read and approved the final manuscript.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

In Finland, according to the current legislation (Medical Research Act 488/1999), register studies with no identifiable individual patients and with no contact with the patients require no ethical committee. approval. Consent to participate was unnecessary, because all patients were anonymized. The Finnish Institute for Health and Welfare maintains the Finnish Hospital

Discharge Register and granted the permission to access the anonymized patient data.

Consent for publication
Consent for publication was unnecessary, because all patients were anonymized.

Competing interests
The authors declare no competing interests.

Author cotributions
P.L. participated in the conception and design of the study, acquisition and analysis of the data, interpretation of data, drafting the and revising the manuscript. K.H. participated in the conception and design of the study, acquisition and analysis of the data, interpretation of data and revising the manuscript draft. P.L. and K.H. read and approved the final manuscript.

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