Increasing Number and Incidence of Fall-induced Severe Head Injuries in Older Adults


Pekka Kannus, Mika Palvanen, Seppo Niemi, Jari Parkkari, Antero Natri, Ilkka Vuori, and Markku Järvinen

To increase knowledge about recent trends in the number and incidence of various fall-induced injuries among older adults, the authors selected from the National Hospital Discharge Register all patients 60 years of age or older who were admitted to hospitals in Finland for primary treatment of a first fall-induced severe head injury during 1970–1995. Similar patients aged 30–39 years served as a reference group. For the study period, the number and incidence (per 100,000 persons) of fall-induced severe head injuries in Finnish persons 60 years of age or older increased considerably (554 and 85, respectively, in 1970 compared with 1,393 and 144, respectively, in 1995). The age-adjusted incidence of these injuries also increased in women, from 80 in 1970 to 125 in 1995, and in men, from 102 in 1970 to 147 in 1995. In the reference group (patients aged 30–39 years), the absolute numbers and incidences of similar injuries did not show consistent trend changes over time. We conclude that the number of fall-induced severe head injuries in elderly Finnish women and men is increasing at a rate that cannot be explained simply by demographic changes, and therefore vigorous preventive measures should be instituted at once to control the increasing burden of these devastating injuries. Am J Epidemiol 1999;149:143–50.

Materials and Methods

Fall-related injuries of older adults are a major public health problem, especially in contemporary Western societies that have aging populations (1–4). As the number of elderly persons in these populations continues to increase, the number of injuries will also increase.

About 30 percent of older adults living in the community and over 50 percent of those living in institutions fall every year, and about 50 percent of those who fall do so repeatedly (3). In nursing homes and related institutions, the mean incidence of falls is 1.5 falls per bed per year (4). Not all falls of older adults are injurious, but 4–5 percent of them result in a fracture, and other serious injuries, such as serious soft tissue injuries, severe lacerations, and head injuries, occur in 5–11 percent of falls (3–8). Of these categories, a fall-related head injury is the most severe (life-threatening) condition. Injury is the fifth leading cause of death in older adults, and most of these fatal injuries are related to falls (3, 4, 6, 9, 10).

In spite of the facts noted above, very little epidemiologic information on fall-induced severe head injuries in elderly persons is available, and no nationwide study investigating the number, incidence, and secular trends of these injuries has been published. Therefore, we determined trends in the absolute number and incidence of fall-induced severe head injuries and the age-specific and age-adjusted incidence rates of these injuries in the 60-year-old and older population in Finland (5 million inhabitants) between 1970 and 1995. We also studied the same figures in a randomly selected reference group (patients aged 30–39 years) to determine whether the possible epidemiologic changes in the study group were specific for the elderly population or just more general time trends in all adult age groups. Our hypothesis was that the number of fall-induced severe head injuries among elderly persons is increasing at a rate that cannot be explained by demographic changes alone.

Materials and Methods

In this epidemiologic study, we defined a fall-induced severe head injury of an elderly adult to be a head injury that occurs in a person 60 years of age or...
older as a consequence of a fall from standing height (1 m) or less and that results in hospitalization of the victim. Similar criteria have been frequently used in epidemiologic studies of osteoporotic fractures of elderly people (1, 2, 11–13). Thus, all patients 60 years of age or older and, from the four remaining adult 10-year age groups (20–29, 30–39, 40–49, and 50–59 years) as a randomly selected younger reference group, all patients aged 30–39 years who were admitted to hospitals in Finland for primary treatment of a fall-induced head injury in 1970–1995 were selected from the National Hospital Discharge Register, the file also including head injury-induced deaths. Unique personal identification numbers allowed us to focus our analysis on each patient's first recorded admission. The National Hospital Discharge Register contains data on age, sex, place of residence, hospital number and department, day of admission and discharge, place and cause of injury, and place of further treatment. Injuries caused by a vehicular accident or other high-energy trauma and injuries not needing hospitalization were excluded. The Finnish National Hospital Discharge Register is the oldest nationwide discharge register in the world, and the data provided by this register are well suited to epidemiologic purposes; that is, the register has been shown to cover the acute injuries of the population adequately (annual coverage of injuries is 95–100 percent) and to record them accurately (annual accuracy of the National Hospital Discharge Register injury diagnoses is over 95 percent), and these percentages are especially good in severe injuries, such as head injuries (14–16).

Fall-induced acute head injuries were recorded from the National Hospital Discharge Register by evaluating the primary and secondary diagnoses and the cause of injury (E-code). According to the directives given by the Finnish National Board of Health, the first diagnosis describes the main reason for the hospital stay. The second, third, and fourth diagnoses indicate other possible diseases or injuries. The diagnoses were labeled with a five-digit code according to the Eighth and Ninth Revisions of the International Classification of Diseases (ICD) that indicated the type of head injury. Between 1970 and 1986, the Eighth Revision of ICD and its following codes were used: 80000–80410 (skull fractures), 85000–85110 (head injuries without fracture), and 85200–85411 (head injuries causing intracranial bleeding). In 1987 and after, the following codes from the Ninth Revision of the ICD were used: 8000A–8033A (skull fractures), 850OA–8519X (head injuries without fracture), and 8520A–8541X (head injuries causing intracranial bleeding).

The data were drawn from the entire population of Finland, the study thus completely covering the intended study population (Finnish nation). In other words, the absolute numbers and incidences of fall-induced severe head injuries were not cohort-based estimates but true final results.

Annual midyear population figures for each 5-year age group (60–64, 65–69, 70–74, 75–79, 80–84, 85–89, ≥90 years) between 1970 and 1995 were taken from the Official Statistics of Finland (17). In each age group, the injury incidence was calculated for both sexes and was expressed as the number of cases per 100,000 persons per year. In calculating the age-adjusted injury incidences, we performed age adjustment by means of direct standardization using the mean population between 1970 and 1995 as the standard population.

Finally, the figures of fracture incidences observed in the different age groups over the study period (1970–1995) were used to predict the age-specific incidences and absolute number of these fall-induced severe head injuries in the population in the years 2000, 2010, 2020, and 2030. The prediction was based on a simple linear trend continuation method using ordinary least squares as the method of regression and $r^2$ and standard error of the estimate as descriptors of the fitness of the regression line to the data. The estimates of the variance did not take into account possible autocorrelation in the data. The prediction was performed by first calculating the incidence regression lines for both sexes and for each age group. These regression lines were then used to determine the age- and sex-specific injury incidences in women and men 60 years of age and over until the year 2030. Then, within each age and sex group, the predicted absolute number of injuries was obtained by multiplying the above-mentioned incidence by the estimate of the number of inhabitants, the latter being obtained from the Finnish "population projections 1995–2030" (18).

RESULTS

Number and incidence of fall-induced severe head injuries

Older adults. In persons 60 years of age or older, the total annual number of fall-induced severe head injuries increased considerably during the study period, from 554 in 1970 to 1,393 in 1995 (figure 1). The average increase was 6.1 percent per year. In general, the incidence curve for injuries also showed an increasing trend, although the Finnish population of persons 60 years of age or older increased 48 percent (from 652,000 to 968,000 persons) during this 25-year period (figure 1). A more detailed examination of the incidence curve revealed that the incidence development actually consisted of four phases: the injury incidence decreased in 1970–1976, sharply increased in
Persons 60 years of age or older

Persons 30–39 years of age

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FIGURE 1. Number and incidence of fall-induced severe head injuries in Finland in persons 60 years of age or older (study group) and persons 30–39 years of age (reference group) between 1970 and 1995.


The overall incidence (per 100,000 persons) of fall-induced severe head injuries in persons 60 years of age or older was 85 in 1970 and 144 in 1995. For women, it was 76 in 1970 and 139 in 1995; for men, it was 100 in 1970 and 152 in 1995. The corresponding age-adjusted incidences were 80 and 125 for women, and 102 and 147 for men, with relative increases of 56 percent in women and 44 percent in men.

When comparing the epidemiologic development of older adults’ fall-induced severe head injuries with that of others or with the severe head injuries induced by mechanisms other than falling, we found additional evidence for the continuously increasing importance of the former. For all severe head injuries in Finland (i.e., all age groups and all causes of severe head injuries included), the proportion of the 60-year-old or older persons’ fall-induced severe head injuries showed a steady increase, from 5 percent in 1970 to 18 percent in 1995. In the population aged 60 years or older, the proportion of fall-induced severe head injuries (of all severe head injuries in this age group) rose from 41 percent to 63 percent. Of all individuals treated in Finnish hospitals for fall-induced severe head injury, the proportion of these older adults increased steadily, from 20 percent in 1970 to 45 percent in 1995.

The mean age of elderly persons with a fall-induced severe head injury also increased during the study period, from 69.6 years in 1970 to 75.0 years in 1995. In women, the mean age increased from 70.7 years in 1970 to 77.1 years in 1995; in men, the mean age increased from 68.3 years in 1970 to 71.9 years in 1995.

**Reference group.** In patients aged 30–39 years, the annual number and incidence of fall-induced severe head injuries did not show an increasing trend by time (figure 1). Early in the 1970s, the number and incidence of these injuries somewhat decreased, after which no notable changes occurred (figure 1).

**Age-specific incidence of fall-induced severe head injuries in older adults**

In the youngest age groups of elderly women and men (60–64 and 65–69 years), the incidence of fall-induced severe head injuries did not show consistent trend changes over time, while in the older age groups, especially in those 80 years of age or older, the injury incidence clearly increased (table 1; figure 2).

**Fall-Induced severe head injuries in older adults in the future**

If the above-noted increase in the injury incidence continues, the total incidences of elderly persons’ fall-induced severe head injuries (per 100,000 inhabitants 60 years of age or older) can be calculated to be 139, 160, 189, and 238 in the years 2000, 2010, 2020, and 2030. Together with the demographic changes, these numbers mean that in the year 2000 the total number of elderly persons’ fall-induced severe head injuries in Finland (5 million population) will be approximately 1,420 and, correspondingly, 2,050, 2,800, and 3,650 in the years 2010, 2020, and 2030 (figure 3). Thus the current number of injuries may almost treble by the year 2030.

**DISCUSSION**

We studied all persons 60 years of age or older in Finland to describe the trends over time for the absolute number and incidence of fall-induced severe head injuries. No such study has been published previously, to our knowledge. We observed that the overall number and incidence (per 100,000 persons) of injuries increased considerably from 554 and 85 in 1970 to 1,393 and 144 in 1995 (figure 1). In both sexes the increase in injury incidence was most pronounced in the oldest age groups, especially in persons 80 years of age and over (figure 2).

A major strength of our study was that injury data were taken from a register (the Finnish National Hospital Discharge Register) with a proven high accuracy and excellent coverage (14–16), and that the reg-
TABLE 1. Number and incidence (per 100,000 individuals) of fall-induced severe head injuries in Finnish women and men 60 years of age and older, by age and year of occurrence

<table>
<thead>
<tr>
<th>Year</th>
<th>Age group</th>
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<th>Men</th>
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<th>Total no.</th>
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Distribution of injuries included the entire population of Finland; that is, absolute numbers and incidences of fall-induced severe head injuries were not cohort-based estimates but true final results. An additional strength of the study was that the elderly patients had a randomly selected reference group (persons 30–39 years of age with similar head injury diagnoses) in which no increasing number and incidence of injuries were seen during 1970–1995 (figure 1). In other words, the behavior of the reference group over time provided rather convincing additional evidence that our National Hospital Discharge Register-based observations on the steeply increasing number and incidence of fall-induced severe head injuries among elderly Finns were real and not due to defects, inaccuracies, or changes in the system of injury registration or to changes in the hospitalization policy of the victims. The steady increase in all three proportional figures of the older adults’ fall-induced severe head injuries (as compared with those of others and with similar injuries induced by mechanisms other than falling) also supported our conclusions (see Results). In addition, a similar time trend has been seen in the number and age-adjusted incidence of hip fractures of the Finnish elderly (19), and these fall-induced injuries have always resulted in hospital admission.

A limitation of our study is that the numbers, incidences, and secular trends of fall-induced severe head injuries of elderly Finns cannot be directly generalized to other populations. However, the incidence of injuries will probably develop similarly in other developed countries. Further studies are required to show precise results for each population. In addition, it should be noted that our database of injuries did not include information on comorbid illnesses, medications, and lifestyles of the patients. In other words, our finding of an increasing incidence of fall-induced severe head injuries among older adults in Finland remained without explanatory speculation.

We feel that our findings on fall-induced severe head injuries among elderly persons are alarming for two reasons. First, not only is the incidence of these fall-induced severe head injuries among elderly people increasing, but the population at risk is constantly expanding and will expand more rapidly in the near future. As a result, the largest age group in Finland (the 15–year cohort born after World War II) will reach the average age of older adults with a severe head injury between the years 2020 and 2030. Second, the increasing mean age of patients who presented with a fall-induced severe head injury is likely to mean more difficulties in the treatment of these injuries (longer time for recovery, longer rehabilitation period, and an increasing number of head injuries with severe com-
FIGURE 2. Age-specific incidence of fall-induced severe head injuries in Finland in women (top) and men (bottom) 60 years of age or older between 1970 and 1995, and prediction of incidences until the year 2030, as calculated with a regression model. In the regression analysis, the women's $r^2$ and standard error of the estimate, from the youngest to the oldest age group, were 0.03 and 10, 0.00 and 11, 0.16 and 16, 0.49 and 24, 0.72 and 30, and 0.78 and 41, respectively. In men, the corresponding values were 0.07 and 20, 0.17 and 20, 0.55 and 20, 0.63 and 28, 0.56 and 50, and 0.50 and 69, respectively.

As we have noted, the precise reasons for the increasing age-adjusted and age-specific incidences of fall-induced severe head injuries in elderly women and men are not known. In the fall-related fractures of the hip, ankle, and proximal humerus, fractures for which a similar secular trend has been reported (13, 19, 20), deterioration in the age-adjusted bone quality (caused by decreased mineral density and bone strength) and an increase in the age-adjusted incidence of falls in the elderly (caused by impaired balance, coordination, proprioception, reaction time, and muscle strength) have been the most commonly offered explanations (19, 21–24). In fall-induced severe head injuries of older adults, only the latter explanation is likely.

We feel that, on average, elderly persons are indeed less healthy today than in the past; thus, persons who now survive to old age are more prone to falls and injuries than were elderly persons in the past. In other words, increased survival of ill and frail elderly indi-
Individuals is likely to mean an increased average tendency to falls and injuries. The increased propensity for falls has been explained by such factors as a higher occurrence of coexisting medical problems, more frequent use of drugs, poorer general mobility (poorer gait and balance), less active lifestyles, and greater consumption of alcohol and other related substances that increase the risk of falling (3–9, 19, 22, 25).

Provided that the observed development in injury incidence continues, the annual number of fall-induced severe head injuries in Finland for persons 60 years of age or older can be estimated to be about 1,420 and 2,050 in the years 2000 and 2010 (figure 3). However, as described above, the largest Finnish age groups will not reach the average age of the patients until the year 2020, and thus the number of these injuries is expected to increase more than linearly during that time. For this reason, vigorous preventive measures, such as diminution of the number and severity of falls of elderly persons, should be implemented at once to control the increasing burden of these age-related injuries.

Some of the first interventions aiming at reducing the number of falls of elderly persons by modifying the predisposing and situational risk factors for falls have shown promising results (6, 26–31), thus giving hope that the increasing number of fall-induced injuries in our modern societies could indeed be controlled. In diminution of fall severity, protection of the head in high-risk individuals (multiple fallers) in situations where falls typically occur could be a reasonable and feasible option. Strategies that reduce elderly persons’ functional independence and mobility through use of physical restraints have been shown to be more harmful than beneficial and should be avoided (4, 5, 32, 33).

In conclusion, the number of fall-induced severe head injuries in elderly Finnish women and men shows an increase with a rate that cannot be explained simply by demographic changes. Effective preventive measures are needed to control this development.

ACKNOWLEDGMENTS

The study was financially supported by the Medical Research Fund of Tampere University Hospital, Tampere, Finland (grants 96/10/9 and 97/4/25).

The authors acknowledge the Finnish Ministry of Health for its cooperation.

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Am J Epidemiol
Vol. 149, No. 2, 1999

Am J Epidemiol Vol. 149, No. 2, 1999