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Educational Inequalities in Post-Hip Fracture Mortality: A NOREPOS Study

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ABSTRACT

Hip fractures are associated with high excess mortality. Education is an important determinant of health, but little is known about educational inequalities in post-hip fracture mortality. Our objective was to investigate educational inequalities in post-hip fracture mortality and to examine whether comorbidity or family composition could explain any association. We conducted a register-based population study of Norwegians aged 50 years and older from 2002 to 2010. We measured total mortality according to educational attainment in 56,269 hip fracture patients (NORHip) and in the general Norwegian population. Both absolute and relative educational inequalities in mortality in people with and without hip fracture were compared. There was an educational gradient in post-hip fracture mortality in both sexes. Compared with those with primary education only, the age-adjusted relative risk (RR) of mortality in hip fracture patients with tertiary education was 0.82 (95% confidence interval [CI] 0.77–0.87) in men and 0.79 (95% CI 0.75–0.84) in women. Additional adjustments for Charlson comorbidity index, marital status, and number of children did not materially change the estimates. Regardless of educational attainment, the 1-year age-adjusted mortality was three- to fivefold higher in hip fracture patients compared with peers in the general population without fracture. The absolute differences in 1-year mortality according to educational attainment were considerably larger in hip fracture patients than in the population without hip fracture. Absolute educational inequalities in mortality were higher after hip fracture compared with the general population without hip fracture and were not mediated by comorbidity or family composition. Investigation of other possible mediating factors might help to identify new targets for interventions, based on lower educational attainment, to reduce post-hip fracture mortality.

KEY WORDS: HIP FRACTURE; MORTALITY; EDUCATION; SOCIOECONOMY

Introduction

Hip fractures are serious because of their subsequent high excess morbidity and mortality.[1,2] Patients with hip fracture have up to eightfold increased risk of all-cause mortality during the first 3 months after the fracture.[2] This excess mortality declines over time but does not return to the age- and sex-comparable mortality in the general population even 10 years after the fracture.[3,4] A better understanding of factors leading to the excess mortality might help develop public health

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NOREPOS (The NORwegian EPidemiologic Osteoporosis Studies) is a collaboration between epidemiologic osteoporosis studies that are substudies within large population-based surveys in four districts of Norway (Tromsø, Nord-Trøndelag, Hordaland, and Oslo). The NOREPOS Hip Fracture Database includes all hospitalizations for hip fracture in Norway.

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interventions to reduce the societal burden of hip fracture. Because of the severity and complexity[2,3,5] of the process leading to excess mortality after a hip fracture, there is a large health potential in the identification of preventable risk factors.

Generally, a subject's position in a social hierarchy affects the vulnerability to ill health and also the consequences of ill health. Income, education, occupation, sex, and race/ethnicity are examples of factors that determine the social position.[6] Length of education is interesting in hip fracture patients because it might affect the health status both before and after the fracture. In the general population, health behaviors such as diet, smoking, and physical activity are considered as mediating factors for educational differences in mortality.[7] Moreover, patients with high educational attainment would have a greater capacity and opportunity to obtain appropriate information that could lead to better-informed choices about prevention as well as treatment in consultation with health professionals,[8] which could improve the chance of surviving a hip fracture.

To the best of our knowledge, only one study has examined the association between educational level and post-hip fracture mortality.[9] There are some studies using other indicators of socioeconomic status (SES) than education, but generally there is inconsistent evidence for an association between SES and post-hip fracture mortality; some studies found increased post-hip fracture mortality in lower compared with higher SES,[10–12] whereas others found no association.[9,13]

We were also interested in three important factors that could be anticipated to mediate any association between education and post-hip fracture mortality: Charlson comorbidity index, marital status, and number of children. Comorbidities are associated with both educational level and post-hip fracture mortality[10,12] and might explain any educational differences in post-hip fracture mortality. Moreover, in the post-hip fracture phase, the patient's family might be protective (through assistance and support from family members) and thus mediate any educational gradient in post-hip fracture mortality. Higher levels of education are linked to larger personal networks among men and women.[14] Both marital status[10,12] and number of family members[15] are associated with post-hip fracture mortality.

The main aim of this study was to investigate the association between educational level and post-hip fracture mortality in the entire Norwegian population, the Norwegian Epidemiologic Osteoporosis Study's hip fracture database (NORHip).[16] Specific aims were (1) to assess the existence and magnitude of inequalities in mortality after a hip fracture according to educational attainment; (2) to examine whether differences in Charlson comorbidity index, marital status, or number of children explained any educational inequalities in post-hip fracture mortality; and (3) to explore any educational inequalities in mortality among hip fracture patients compared with age-, sex-, and education-specific mortality in the general population without fracture.

Materials and Methods

Hip fractures

Data on hip fractures treated in Norway during 1994 to 2008 were retrieved through a system developed by the Norwegian Knowledge Centre for the Health Services. To avoid immortal time bias (follow-up time during which death cannot not occur because of exposure definition), only hip fractures sustained after the population and housing census 2001 were included (ie, from January 1, 2002, through December 31, 2008). The study population was also restricted to those aged 50 years and older at the time of fracture. Discharge diagnoses were retrieved from the Patient Administration Systems (PAS) from all 48 hospitals and health trusts in Norway treating hip fracture patients. Additional diagnosis codes (International Classification of Diseases, Tenth Revision [ICD-10]: S72.0-S72.2) and surgical procedure codes obtained from PAS were used to distinguish admissions for new hip fractures from rehospitalizations for the same fracture[17] in the NORHip database (NOREPOS Hip Fracture Database) (www.norepos.no).

Charlson comorbidity index

A modified Charlson index[18] was constructed based on specific diagnoses registered during the hospitalization for hip fracture. The following diagnoses were included in the Charlson comorbidity score: cardiovascular disease (acute myocardial, congestive heart failure, peripheral vascular, cerebrovascular), diabetes (with/without complications), chronic obstructive lung disease, dementia, rheumatoid disease, peptic ulcer, hemiplegia or paraplegia, renal disease, cancer (with/without metastasis), liver disease (mild/moderate/severe). The Charlson index takes into account the total number of specific diagnoses and the severity of these (1 to 6 points). The index was categorized in four groups: 0 points (none of the specific diagnoses), 1 point, 2 points, and 3 or more points.

Dates of death and emigration

The National Population Register provided death and emigration dates of the entire Norwegian population from January 1, 2002, through December 31, 2010.

Demographic and educational information

Information on educational level for the entire Norwegian population aged 50 years and older was obtained from the population and housing census 2001. In this age group, the primary education started at age 6 to 7 years. Educational level, categorized in nine categories by Statistics Norway,[19] was recoded into three categories: primary education (0 to 9 years of education) only, secondary education (10 to 12 years of education), and tertiary education ($\geq$13 years of education). In total, the 2001 census had registered 56,946 subjects who later suffered a hip fracture from 2002 to 2008. Only 677 (1.2%) of the hip fracture patients had missing information on education in 2001 and were excluded.

Information on marital status was categorized as married, never married, and previously married. Previously married means previously married but currently unmarried. Number of children was categorized as no children, 1 to 2 children, and 3 or more children.

Statistics

The statistical package Stata 13 (StataCorp, College Station, TX, USA) was used to analyze the data. One-way ANOVA and chi-square tests were used to test for statistical differences in age at fracture, number of children, and marital status between education categories. A Poisson model adjusted for age at the time of fracture with Charlson comorbidity index as dependent variable was used to analyze comorbidity by educational category. Median survival times were computed with the Stata function *stci*.

Age-standardized mortality rates were calculated for the time intervals 0 to $\leq$1 year, 1 to $\leq$5 years, and 5 to 9 years post-hip fracture and also in the age strata 50 to 64 years, 65 to 79 years, and 80 years and older. Regression models were used to examine mortality by education category among the hip fracture patients (in total and in the age strata 50 to 64 years, 65 to 79 years, and 80 years and older). Best-model fit was obtained with Poisson models. The incidence rate ratios obtained from the models (ie, relative mortality estimates) are called relative risks (RRs) hereafter. All models were adjusted for age at the time of fracture. The models were either performed separately for women and men or were adjusted for sex when sex-stratified analyses gave similar results. Separate models with additional adjustments for marital status, number of children, or Charlson index were performed and compared with the unadjusted estimates to test for mediation. However, because the Poisson is a nonlinear model, testing for mediation is a more complex matter than with linear models.[20] At present, there is no function available to analyze mediation effects for Poisson models including person time. However, because adjustments for the potentially mediating variables did not change the educational differences in post-hip fracture mortality, the presence of significant mediation effects are unlikely and further mediation analyses were, therefore, not performed.

Standardized mortality ratios (SMR) by educational attainment among the hip fracture patients were expressed relative to age-, year-, and sex-specific mortality in the corresponding education category in the overall population without hip fracture. Separate calculations were performed for $<$1 year post-hip fracture and $\geq$1 to 9 years post-hip fracture mortality, respectively.

One-year mortality in 5-year age groups in the hip fracture patients and mortality in 5-year age groups in the general population were age-standardized. The number of deceased subjects and number of person-years in the hip fracture patients were subtracted from the corresponding age-specific population figures to obtain mortality estimates in the population with and without hip fracture.

Ethics

The Norwegian Data Protection Authority, the Directorate of Health, Statistics Norway, and the Regional Committee for Medical and Health Research Ethics approved the study.

Results

A total of 16,551 men and 39,718 women aged 50 years and older with information about education sustained a hip fracture between 2002 and 2008. Mean age at fracture was lower (3 to 4 years) in those with the highest compared with the lowest educational level in both sexes (Table 1).

All-cause mortality post-hip fracture by attained educational level

After adjusting for age at the time of fracture, there was a significant negative association between educational level and post-hip fracture mortality (Table 2), and the educational gradient in the post-hip fracture mortality was present in both men ($p < 0.001$) and women ($p < 0.001$). Adjustments for Charlson comorbidity index, marital status, and number of children did not materially change the association between educational level and mortality post-hip fracture in sex-combined or stratified analyses (data not shown).

The relative differences in post-hip fracture mortality by educational category were greatest in those who fractured at younger ages (Table 3). However, when presenting age-standardized mortality rates, the absolute differences were greater in the oldest compared with the youngest hip fracture patients.

Time-specific post-hip fracture mortality by attained educational level

Mortality rates, as expected, were highest in the first year after hip fracture (Fig. 1). However, higher education was associated with lower mortality rates at all examined time points; the age- and sex-adjusted RR in hip fracture patients with tertiary versus primary education was 0.82 (95% confidence interval [CI] 0.77–0.87), 0.79 (95% CI 0.75–0.85), and 0.79 (95% CI 0.69–0.90) for $\leq$1 year, 1 to $\leq$5 years, and 5 to 8 years after the hip fracture, respectively.

Excess mortality by attained educational level

Contrary to the mortality rates (Fig. 1), the relative mortality risk (SMR) in hip fracture patients compared with peers in the general population tended to be highest in those with tertiary education (Table 4).

In absolute terms, the differences in mortality rates between the primary and tertiary education group were larger in hip fracture patients during the first year after fracture compared with those in the general population (Fig. 2). The age-standardized rate difference in 1-year mortality between hip fracture patients with primary versus tertiary education was 477 (95% CI 324–627) per 10,000 in men and 316 (95% CI 214–418) per 10,000 person-years in women. The corresponding age-adjusted rate differences in the general population were 119 (95% CI 116–122) per 10,000 person-years in men and 83 (95% CI 79–87) per 10,000 in women.

Discussion

In this large population study of 56,269 Norwegian hip fracture patients aged 50 years and older, there was a strong educational gradient in post-hip fracture mortality. The educational gradient persisted throughout 9 years of follow-up. Charlson comorbidity index, marital status, or number of children did not explain the educational inequalities observed in the hip fracture patients. The 1-year mortality in hip fracture patients compared with peers in the general population without fracture was three- to fivefold increased irrespective of educational attainment. However, the absolute educational inequalities in post-hip fracture mortality were considerably larger than the comparable inequalities in the Norwegian population without hip fracture.

Comparison with other studies

To the best of our knowledge, only one previous study investigated the association between educational attainment and post-hip fracture mortality.[9] Using Italian register data ($n = 6896$) Castronuovo and colleagues reported that the mortality of hip fracture patients with more than 8 years of education did not differ significantly from that of patients with 8 years of education or fewer (RR = 0.94, 95% CI 0.67–1.30).[9] This finding is not in line with that of the current study. It is

Table 1. Descriptive Data According to Attained Educational Level in 56,269 Norwegian Men and Women Aged 50 Years and Older With a Hip Fracture (The Norwegian Epidemiologic Osteoporosis Studies)

	Educational level			
	Primary	Secondary	Tertiary	*p* Value[a]
Men				
No. with hip fracture	7250	7272	2029	
No. deceased	5238	4573	1198	
No. of person-years	18,349	20,729	6141	
Mean age (years) at time of fracture	80.4	77.6	77.1	<0.001
Mean no. of children	1.8	1.9	2.1	<0.001
Marital status				
Never married (%)	16	10	5	
Married (%)	53	61	70	
Previously married (%)	32	29	25	<0.001
Charlson index[b]				
No comorbidities[c] (%)	44	47	52	
1 comorbidity (%)	29	28	26	
2 comorbidities (%)	15	13	12	
≥3 comorbidities (%)	12	12	10	<0.001
Women				
No. with hip fracture	22,175	14,705	2838	
No. deceased	13,727	7711	1269	
No. of person-years	72,177	52,057	10,746	
Mean age (years) at time of fracture	82.8	80.2	78.3	<0.001
Mean no. of children	1.8	1.8	1.7	0.003
Marital status				
Never married (%)	7	9	17	
Married (%)	28	36	40	
Previously married (%)	65	55	43	<0.001
Charlson index[b]				
No comorbidities[c] (%)	52	57	62	
1 comorbidity (%)	31	28	25	
2 comorbidities (%)	12	10	8	
≥3 comorbidities (%)	5	5	4	<0.001

[a]Difference between the educational levels.
[b]Adjusted for age at the time of first fracture.
[c]None of the comorbidities included in the Charlson comorbidity index were recorded during the hospitalization for hip fracture.

possible that the Italian study did not have sufficient statistical power or that the association between hip fracture mortality and education varies between countries.

Other indicators of SES than education can also be used, such as income or occupational class, albeit measuring different aspects of SES.[21] Some studies have reported an association between SES and post-hip fracture mortality,[10–12] whereas others have not.[9,13]

Patients in the tertiary education group were younger when fracturing compared with those with primary education only. This

Table 2. Survival Time and Relative Post-Hip Fracture Mortality by Attained Educational Level in Norwegian Men and Women Aged 50 Years and Older, 2002–2010 (The Norwegian Epidemiologic Osteoporosis Studies)

Education	No. of hip fractures	Median survival time (years) (95% CI)	Crude RR (95% CI)	Age-adjusted RR (95% CI)
Men				
Primary	7250	2.2 (2.0–2.3)	1.00	1.00
Secondary	7272	3.0 (2.9–3.2)	0.77 (0.74–0.80)	0.91 (0.88–0.94)
Tertiary	2029	3.6 (3.3–3.9)	0.68 (0.64–0.72)	0.82 (0.77–0.87)
Women				
Primary	22,175	3.7 (3.7–3.8)	1.00	1.00
Secondary	14,705	4.8 (4.7–5.0)	0.78 (0.76–0.80)	0.89 (0.87–0.92)
Tertiary	2838	6.2 (5.8–6.8)	0.62 (0.59–0.66)	0.79 (0.75–0.84)

CI = confidence interval; RR = relative risk.

Table 3. Age-Specific Mortality and Relative Post-Hip Fracture Mortality by Attained Educational Level in Norwegian Men and Women Aged 50 Years and Older, 2002–2010 (The Norwegian Epidemiologic Osteoporosis Studies)

	Age-standardized mortality per 10,000			Age-adjusted RR (95% CI)		
Age group (years)	50–64	65–79	80+	50–64	65–79	80+
Men						
Primary	35	255	1503	1.0	1.0	1.0
Secondary	29	214	1333	0.83 (0.69–1.00)	0.89 (0.82–0.96)	0.92 (0.88–0.96)
Tertiary	20	164	1235	0.60 (0.45–0.80)	0.77 (0.68–0.87)	0.86 (0.79–0.93)
Women						
Primary	108	591	1918	1.0	1.0	1.0
Secondary	89	527	1732	0.86 (0.71–1.03)	0.84 (0.79–0.89)	0.91 (0.88–0.94)
Tertiary	62	432	1652	0.55 (0.41–0.75)	0.70 (0.62–0.79)	0.83 (0.78–0.89)

CI = confidence interval; RR = relative risk.

is likely to be a demographic phenomenon resulting from a general inverse association between age and educational attainment in the older Norwegian population, ie, a smaller proportion of the oldest generation attained tertiary education. Consequently, a larger proportion of the hip fractures in the high education group would thus occur among a relatively younger population. However, if there is a causal link between educational attainment and age at hip fracture, a possible explanation may be that subjects with tertiary education are more likely to have a lower body mass index compared with those with primary education only.[22] Low body mass index is an important risk factor for fracture,[23] and this might explain the lower age at fracture. However, in a systematic review, there was inconsistent evidence for an association between SES and hip fracture.[24]

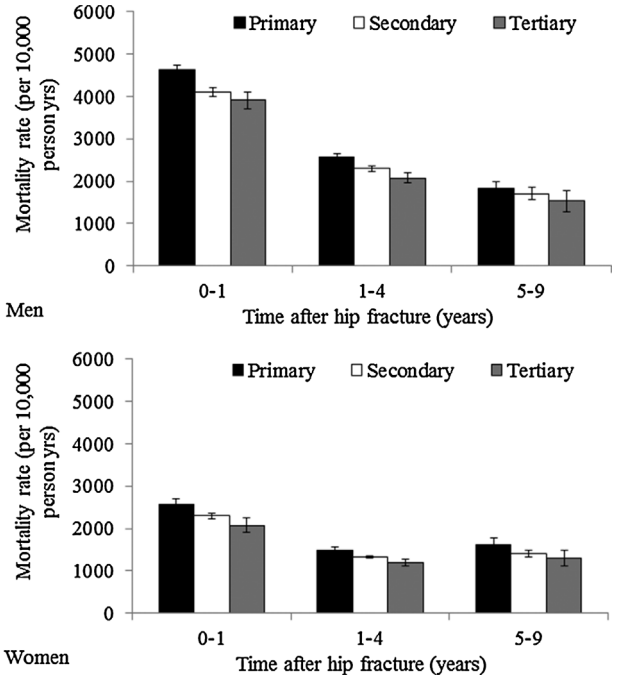

Fig. 1. Age-standardized mortality rates per 10,000 person-years with 95% confidence intervals by attained educational level (primary, secondary, tertiary) and time after hip fracture in men and women aged 50 years and older at the time of fracture. The Norwegian Epidemiologic Osteoporosis Studies.

Interpretation of the results

In the present study, the *relative* educational differences in mortality among hip fracture patients were smaller than in the general population. However, because the post-hip fracture mortality is high, comparing relative educational differences does not provide a complete picture. In the primary compared with the tertiary education group, there were 30 to 50 more deaths per 10,000 person-years in hip fracture patients, whereas the corresponding numbers in the general population were 8 to 12. This means that any inequality in the burden of excess mortality that is related to hip fracture is substantially increased compared with the general population without hip fracture. This indicates that preventive strategies aiming to reduce educational inequalities in exposure to those factors that affect mortality among hip fracture patients are likely to have an impact on overall post-hip fracture mortality.

In general, higher education is associated with better health and lower mortality, and this association is partly explained by a healthier lifestyle in those with higher education (better diet, more exercise, and less smoking).[25,26] The educational gradient in post-hip fracture mortality might, at least partly, be mediated by differences in lifestyle. It is also possible that highly educated subjects have relatives arranging better care for them. However, Charlson comorbidity index, marital status, or number of children could explain the educational mortality gradient in the current study. The results regarding comorbidity are supported by a large Danish study reporting that the excess mortality post-hip fracture is mainly caused by factors linked to the event and not to preexisting comorbidity.[12]

Differences in use of health care services after hip fracture may mediate part of the educational mortality inequalities, and this area needs further investigation. Bisphosphonate treatment, for example, has been shown to be associated with reduced mortality.[27] Devold and colleagues found that adherence to alendronate treatment was significantly higher in women with higher compared with lower income, whereas middle education was an important predictor of adherence in men.[28] Given the recent data on bisphosphonate therapy and reduced premature mortality,[29–31] this should be explored further.

Strengths and limitations

Strengths of this study include its large size, including all hip fractures treated in Norwegian hospitals from 2002 to 2008. In the present study, education was chosen as a measure of SES because education is more likely to be associated with health-

Table 4. Standardized Mortality Ratios in Hip Fracture Patients Relative to the Expected Age-, Sex-, and Education-Specific Mortality in the General Population Without Hip Fracture (The Norwegian Epidemiologic Osteoporosis Studies)

	0–12 months		1–9 years	
Education	No. deceased	SMR (95% CI)	No. deceased	SMR (95% CI)
Men				
Primary	2657	4.7 (4.6–4.9)	2581	1.8 (1.8–1.9)
Secondary	2206	5.1 (4.9–5.3)	2367	2.1 (2.0–2.2)
Tertiary	577	5.6 (5.2–6.1)	621	2.1 (1.9–2.3)
Women				
Primary	5088	3.0 (2.9–3.1)	8639	1.5 (1.5–1.6)
Secondary	2773	3.3 (3.1–3.4)	4938	1.6 (1.6–1.7)
Tertiary	457	3.3 (3.1–3.7)	812	1.6 (1.5–1.7)

CI = confidence interval; SMR = standardized mortality ratio.

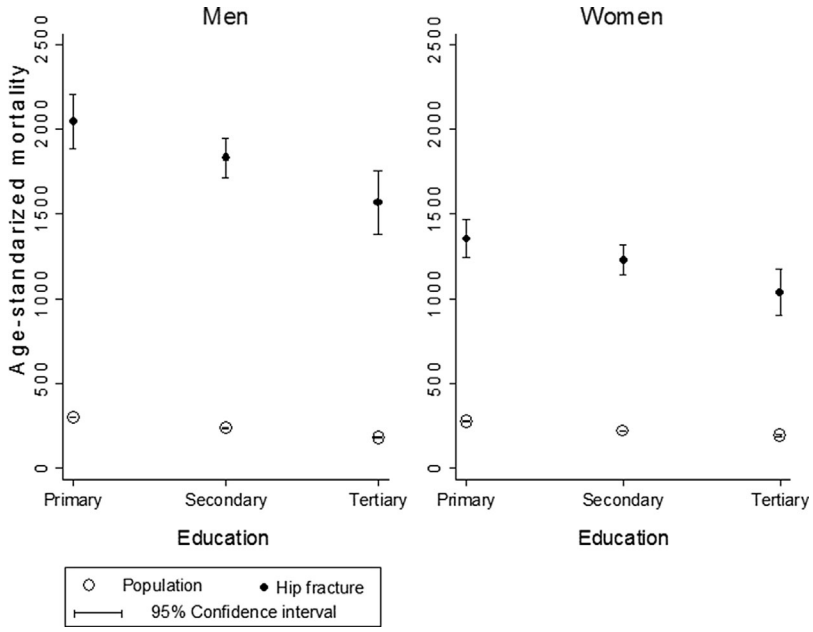

Fig. 2. Age-standardized 1-year mortality per 10,000 person-years with 95% confidence intervals in hip fracture patients and in the general Norwegian population (free of hip fracture) by attained educational level (primary, secondary, tertiary). The Norwegian Epidemiologic Osteoporosis Studies.

seeking behavior than occupation or wealth per se. Furthermore, education is a precise and stable measure shown to be associated with mortality in the general population.[32] However, it is possible to have low education but still have a high SES (especially in older women). Because information about marital status was only available in 2001, this might have changed by the time of fracture. A possible limitation is that the categorization of education assumes constant effects over time, although it might be that education has a different impact on health now than previously. Stratifying the data by age cohort showed an educational gradient in all subgroup analyses, although the RRs were greatest in the youngest cohorts (data not shown).

A strength of the study is that the quality of the hip fracture database has been validated and showed good agreement with medical chart and X-ray-verified hip fractures.[17] It is also a strength that we have information on education on the vast majority of the hip fracture patients (98.8%) in the country during this period and also on the entire population without hip fracture. One limitation is the lack of information about possible mediators of the educational differences in mortality such as compliance to treatment, physical activity, smoking, and nutrition. We would also have liked to have had information about clinical risk factors and other SES indicators that could have helped explain the educational differences. Charlson comorbidity index could not explain the differences in mortality between the education categories. However, the Charlson index was based on comorbidities registered during the hospitalization for hip fracture (ie, diagnoses relevant for the hospitalization). Consequently, the registration may not be a complete measure of all comorbidities, and it is possible that comorbidities explain more of the differences in mortality. However, this bias would have to be very large and differ by education category to influence the conclusions of the study.

Moreover, it is possible that adjustment for additional or a different combination of comorbidities could have some impact on the results. But, because Charlson index (1) was strongly related to post-hip fracture mortality, (2) contains the most common and serious diagnoses, and (3) no difference in the estimates were observed after adjustments, such an impact is likely to be small.

In conclusion, there was a clear educational gradient in post-hip fracture mortality. Compared with peers in the general population, the excess mortality post-hip fracture was higher in all educational groups. However, in absolute terms, the increased mortality risk in the lower educational group was higher in the hip fracture patients compared with the general population without hip fracture, suggesting a potential high-risk target group for intervention, based on lower educational background.

Disclosures

All authors state that they have no conflicts of interest.

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Authors' roles: TKO: acquisition of data, conception and design, analyses and interpretation of data, and drafting the manuscript. TKO also accepts responsibility for the integrity of the data analysis. HEM, KH, and AJS: acquisition of data, conception and design, interpretation of data analyses, critically revising the manuscript, and approval of the final version of the manuscript. GST, ØN, SF, BS, JC, JAE, CGG, NE, and JEM: interpretation of data analyses, critically revising the manuscript, and approval of the final version of the manuscript.

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