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Injury severity and increased socioeconomic differences: A population-based cohort study

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ABSTRACT

Background: Several studies have documented an inverse gradient between socioeconomic status (SES) and injury mortality, but the evidence is less consistent for injury morbidity. The aim of this study was to investigate the association between SES and injury severity for acute hospitalizations in a nationwide population-based cohort.
Methods: We conducted a registry-based cohort study of all individuals aged 25–64 years residing in Norway by 1st of January 2008. This cohort was followed from 2008 through 2014 using inpatient registrations for acute hospitalizations due to all-cause injuries. We derived two measures of severity: threat-to-life using the International Classification of Disease-based Injury Severity Score (ICISS), and threat of disability using long-term disability weights from the Injury-VIBES project. Robust Poisson regression models, with adjustment for age, sex, marital status, immigrant status, municipality population size and healthcare region of residence, were used to calculate incidence rate ratios (IRRs) by SES measured as an index of education, income, and occupation.
Results: We identified 177,663 individuals (7% of the population) hospitalized with at least one acute injury in the observation period. Two percent ($n = 4{,}186$) had injuries categorized with high threat-to-life, while one quarter ($n = 43{,}530$) had injuries with high threat of disability. The overall adjusted IRR of hospitalization among people with low compared to high SES was 1.57 (95% CI 1.55, 1.60). Comparing low to high SES, injuries with low threat-to-life were associated with an IRR of 1.56 (95% CI 1.54, 1.59), while injuries with high threat-to-life had an IRR of 2.25 (95% CI 2.03, 2.51). Comparing low to high SES, injuries with low, medium, and high threat of disability were associated with IRRs of respectively, 1.15 (95% CI 1.11, 1.19), 1.70 (95% CI 1.66, 1.73) and 1.99 (95% CI 1.92, 2.07).
Discussion: We observed an inverse gradient between SES and injury morbidity, with the steepest gradient for the most severe injuries. This suggests a need for targeted preventive measures to reduce the magnitude and burden of severe injuries for patients with low socioeconomic status.

Introduction

Injuries constitute a major public health problem. In Norway, injuries are the most common cause of death among people aged 45 or younger [1], and 12 percent of the population receives healthcare treatment for injuries each year [2]. Non-fatal injuries contribute substantially to reduced quality of life for the injured as well as high costs to society [3–5]. This includes long-term disability, which affects health-related quality of life and the ability to return to full employment [6,7].

The burden of injury affects all social groups, but particularly individuals with low socioeconomic status (SES) [8]. Socioeconomic status is defined as a hierarchical continuum of socially positive values used to reflect a person's position in society [9]. It is usually measured using data on education, income, and occupation, either as separate proxy measures, or as one singular composite measure [10]. Research over several decades has established that low SES is linked to restricted autonomy over both life circumstances and access to knowledge that promotes beneficial health behavior [11]. Individuals scoring lower on SES have worse self-reported health

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[12] and lower life expectancy [13], suffer from more chronic conditions [14,15], receive fewer diagnostic tests and medications for many chronic diseases [16,17], and have limited access to health care due to cost and coverage [18].

Several studies have reported an inverse gradient between SES and injury mortality rates [19–22], where individuals with low SES are at greater risk of fatal injuries. However, the evidence is less consistent for injury morbidity rates [8,23–27], with some studies even observing increased injury incidence for the highest SES groups [28]. Moreover, there is evidence to suggest that the association between injury morbidity and SES may vary according to injury severity. Using data from the US National Health Interview Survey (1987–1994), Cubbin and colleagues found that low education was associated with an increased risk only for the most severe injuries (those resulting in five or more days of restricted activities) [19]. Likewise, in a study on non-fatal car crashes among young Swedish adults, the reported differences by SES were more pronounced with higher injury severity [29]. Other studies have found that patients with lower SES more often have injuries that result in more complex care [30] and poorer recovery [31].

Pursuing this line of inquiry, the aim of this study was to investigate the relationship between injury severity and SES in a nationwide population-based cohort, assessing injury severity along two dimensions: threat-to-life and threat of long-term disability.

Materials and methods

We adhered to the STROBE guidelines for reporting cohort studies [32].

Data sources

Everyone who has lived in Norway at any time since 1964 has been assigned an 11-digit personal identification number and are included in the National Population Register. This register contains information on among other things: births, names, paternity and parental responsibility; changes of address; changes in marital status; deaths; name changes; citizenship.

In this cohort study, we linked census data from the National Population Registry [33] and other sociodemographic information supplied by Statistics Norway with injury diagnoses obtained from the Norwegian Patient Registry (NPR) using unique personal identification numbers ensuring correct linkage at the individual level. NPR contains data from all Norwegian hospitals and outpatient clinics from 2008 onwards, including dates of discharge from the hospital or outpatient visit. All diagnoses are coded according to *the International Classification of Diseases, 10th Revision* (ICD-10).

Study population

The study population was a closed cohort of all individuals aged 25–64 years residing in Norway as of 1st of January 2008. We restricted the study sample to this age range as younger age groups may not have obtained a stable socioeconomic status, and many older residents have retired.

Outcomes: acute hospitalization for injuries by level of severity

From NPR, we retrieved date of hospitalization and vital status at discharge for all patients with ICD-10 codes S00-T78 (chapter XIX) as principal diagnosis in the years 2008–2014. Complications and sequelae (T79-T98) were excluded from the analyses. To identify the most severe injury episode we further restricted the analyses to urgent hospital admissions.

We derived two severity measurements: *threat-to-life* and *threat of long-term disability*. The first, threat-to-life, was calculated using survival risk ratios from population-based hospital admissions data and applying the widely used International Classification of Diseases-based Injury Severity Score (ICISS) [34]. The ICISS is a tool used to determine and compare injury severity. It uses survival risk ratios (SRRs) that are empirically derived for each ICD code to estimate an individual's probability of survival. This injury severity score measure has been shown to perform well compared to other injury severity scores [34,35], and the method is described in detail elsewhere [34]. To this end, we used admissions from acute hospitalizations due to injuries in the period 2008–2014 registered in the NPR's hospital discharge administrative database (N = 218,607 injury ICD-10 codes), and deaths registered at the hospital or within 30 days after discharge (N = 789) registered in the Norwegian Cause of Death Registry [36]. Each patient's threat-to-life (ICISS-score) was then calculated as the product of the probabilities of surviving each of their injuries individually per injury episode. For some patients, the ICISS coincided with a single SRR, for others it was the product of multiple SRRs based on their present diagnoses. We followed the methodology of Stephenson and colleagues [34] and defined cases with serious injury as patients hospitalized with an ICISS of less than or equal to 0.941, indicating an expected mortality of 5.9 percent or greater at 30 days after discharge. This group of patients were likewise defined as the most severely injured in our analyses using ICISS. The remaining cases of acute hospitalizations with an expected survival higher than 0.941, were defined as less severe compared to the first group.

The second injury severity measurement we included was threat of disability. For this outcome we used long-term disability weights [37] from the Validating and Improving Injury Burden Estimates Study (Injury-VIBES) project [38]. The included disability weights are described in detail elsewhere [39]. Briefly, the Injury-VIBES project combined data from several studies to calculate disability weights based on patients' self-reported health status. The disability weights were summed to provide an annualized or time-averaged disability weight for both individual and grouped ICD-10 diagnosis codes, using established nature of injury classifications. We included 12-month annualized disability weights for cases discharged after hospital admission. These disability weights are assumed to be indicative of permanent health loss, where diagnoses with the highest weights are expected to coincide with increased risk of long-term disability. The quintile distribution of the disability weights was categorized to reflect risk of permanent health loss: high risk (quintile 1), medium risk (quintiles 2 through 4) and low risk (quintile 5) (for further details, see Table 1 in the Supplement). Since disability weights were unavailable for some ICD-10 codes in the Injury-VIBES study, eligible cases were defined as the first hospitalization with a diagnosis registered with a long-term disability weight (for further details, see Table 2 in the Supplement).

Exposure: composite measure of socioeconomic status

Based on information as of January 1st, 2008, each person in the cohort was assigned a SES-score using an approach similar to the multidimensional index developed by Lampert and colleagues [40]. This approach combines information across the three dimensions of education, income, and occupation, into a composite measure of SES.

Educational attainment was obtained from the National education database and categorised in nine groups using the standard classification from Statistics Norway [41], ranging from no education/pre-school education to postgraduate education. Occupation was obtained from Statistics Norway's event database [42] and likewise categorised into nine groups using the standard classification of occupation from Statistics Norway [43], ranging from elementary and armed forces occupations to managers. Information on occupation is missing in the event database for self-employed individuals. Disposable income after tax, including any received monetary social benefits, was categorized into nine quantiles with the first quantile defining the lowest and the ninth quantile defining the highest income level (for further details, see Table 3 in the Supplement).

To calculate the SES index, the point scores of the three subscales — education, occupation, and income — were summed to compute a total score with a possible range of 3 through 27. For individuals with missing values on one of the three SES dimensions (14,7 percent), a value was assigned based on the average of observed values on the other two dimensions. Likewise, for individuals with missing values on two dimensions (0,8 percent), a composite score was computed by multiplying the observed value by three.

Finally, the total score was divided into three categories: "low SES" (quintile 1), "middle SES" (quintiles 2–4) and "high SES" (quintile 5). For further details, see Table 4 in the Supplement.

Covariates

We included the following covariates (all based on information as of 1st of January 2008): sex, age, marital status, immigrant status, municipality population size and healthcare region of residence. Age was categorised into five-year age groups (ranging from 25 to 29 through 60–64 years of age). Marital status was dichotomized as married or unmarried [44]. Immigrant status was included as two categories: immigrant background defined as individuals either born outside Norway by two foreign-born parents or born in Norway by two foreign-born parents, and the rest of the population [45].

The municipality of residence was classified into 6 categories using population size per 2008: less than 2000 inhabitants, 2000 through 4999 inhabitants, 5000 through 9999 inhabitants, 10,000 through 19,999 inhabitants, 20,000 through 49,999 inhabitants, and 50,000 inhabitants or more. Finally, cohort members were assigned to one of four healthcare regions: North, Central, West, and South-East.

Statistical analysis

Person-time at risk accumulated from the start of follow-up on 1st January 2008 until acute hospitalization from an injury, emigration, death, or end of follow-up on 31st December 2014, whichever occurred first.

The results were expressed as numbers and rates per 10,000 person-years (py) in the population for acute hospitalizations with injury according to SES, first overall and then separately for our two measures of injury severity: threat-to-life (high/low) and threat of long-term disability (high/medium/low).

We used robust Poisson regression with the sum of person-years at risk as an offset to examine incidence rate ratios (IRRs) and corresponding 95% confidence intervals (CIs) for the outcome measures for each level of the composite SES measurement, with the highest SES quintile as reference group. The models were adjusted for potential confounders; sex ($N = 2$), age group ($N = 8$), marital status ($N = 2$), immigrant status ($N = 2$), county of residence population ($N = 6$), and healthcare region of residence ($N = 4$).

To assess the robustness of our results to changes in SES during the period from 2008 through 2014, we calculated a second SES-measurement using information on education, income and occupation registered at the end of the follow-up depending on year of censoring from the study. We compared the two SES-measurements and performed three separate sensitivity analyses for acute hospitalization from injury restricting the analysis to a) people with an upward change in their SES-index score, b) people with no change in their SES-index, and c) people with a downward change in their SES-index.

The R software package, version 4.1.1 [46] was used for data analysis.

Results

The study population comprised 2535,213 individuals, of whom 55,830 died during follow-up and 40,252 emigrated and were lost to follow-up. Cohort characteristics are presented in Table 1. A total of 198,938 individuals were admitted to hospital at least once for a new acute injury treatment during follow-up. Of these, 21,275 patients had ICD-10 codes lacking disability weights in the Injury-VIBES study and were thus excluded, leaving 177,663 patients for analysis. The correlation between the ICISS-score and the Injury-VIBES disability weight-score was moderate ($r = 0.418$, $p<0.001$).

Men had a higher incidence rate of hospitalizations with injuries, with 116 cases per 10,000 py compared to 88 cases per 10,000 py for women. The risk increased with age, with 135 cases per 10,000 py for the oldest age group (60–64 years) compared to 97 cases per 10,000 py for the youngest (25–29 years). The risk of injury was lower for married individuals with 92 cases per 10,000 py compared to 113 cases per 10,000 py among individuals not married. Immigrants had lower risk with 88 cases per 10,000 py compared to 104 cases per 10,000 py for the rest of the population. Individuals living in the most populated municipalities (50,000 or more inhabitants) had the lowest risk with 95 cases per 10,000 py compared to 111 cases per 10,000 py for people living in the least populated municipalities (less than 2000 inhabitants). There was an increased risk of hospitalization for injury with 109 cases per 10,000 py for individuals living further north in Norway (healthcare regions North and Central), compared to people living in the southern parts of Norway (healthcare regions West and South-East) with 90 and 104 cases per 10,000 py respectively.

Table 2 shows the incidence rates and IRRs for acute hospitalization from injury by SES. Compared with people in the highest SES category, all other groups had an increased risk of acute hospitalization due to injury. The crude incidence rate for people in the lowest SES category was 127 cases per 10,000 py compared to 84 cases per 10,000 py for people in the highest SES category. After adjusting for sex, age group, marital status, immigrant status, municipality population size and healthcare region of residence, people in the lowest SES category had a 57% increase in risk compared to people in the highest SES category (adjusted IRR (aIRR)=1.57 95% CI: 1.55, 1.60).

The IRRs for the acute hospitalizations by SES and injury severity measured as threat-to-life using ICISS are shown in Table 3. A total of 2.4% ($N = 4186$) of the patients were classified as having injuries with high threat-to-life using the ICISS-score (Model 1). Compared with people in the highest SES category, all other SES categories were associated with an increased risk of injuries of the corresponding severity level, with above twice the increase in risk for people in the lowest SES category (aIRR=2.25 95% CI: 2.03, 2.51). The same trend with increased risk of acute hospitalization with decreasing SES was also present for patients with injuries classified as low threat-to-life (Model 2, $N = 173,477$), but not as steep as for patients with injury diagnoses associated with high threat-to-life. Compared to people in the highest SES category, people belonging to the lowest SES category in Model 2 had an increased risk of 56% (aIRR=1.56 95% CI: 1.54, 1.59) (Table 3).

The IRRs for the acute hospitalizations by SES and injury severity measured as threat of long-term disability using disability weights from Injury-VIBES are shown in Table 4. A total of 20.6% ($N = 36,573$) of the patients were classified with high threat of

Table 1
Crude cohort characteristics as of January 1st, 2008.

	Residents			Acute hospitalization from injury[c]		
	No.	%	No. person-years[b]	No. Cases	%	Incidence Rate[d]
Total	2 535 213	100,0	17 409 193	177 663	100,0	102.1
Sex						
Female	1 245 417	49,1	8 587 720	75 113	42,3	87.5
Male	1 289 796	50,9	8 821 473	102 550	57,7	116.3
Age						
25–29 y	295 564	11,7	2 021 702	19 504	11,0	96.5
30–34 y	320 017	12,6	2 202 089	19 296	10,9	87.6
35–39 y	361 942	14,3	2 501 631	22 407	12,6	89.6
40–44 y	351 120	13,8	2 428 299	22 754	12,8	93.7
45–49 y	323 602	12,8	2 233 847	21 981	12,4	98.4
50–54 y	311 636	12,3	2 142 885	22 752	12,8	106.2
55–59 y	292 673	11,5	1 999 405	23 633	13,3	118.2
60–64 y	278 659	11,0	1 879 336	25 335	14,3	134.8
Marital status						
Married	1 320 982	52,1	9 094 907	83 543	47,0	91.9
Unmarried	1 214 231	47,9	8 314 286	94 120	53,0	113.2
Immigrant status						
Immigrants[a]	282 501	11,1	1 847 105	16 191	9,1	87.7
Non-immigrants	2 252 712	88,9	15 562 088	161 472	90,9	103.8
Municipality size						
Less than 2000 inhabitants	57 686	2,3	396 788	4 384	2,5	110.5
2000 through 4999 inhabitants	228 896	9,0	1 576 886	17 192	9,7	109.0
5000 through 9999 inhabitants	330 658	13,0	2 278 722	24 051	13,5	105.5
10,000 through 19,999 inhabitants	411 673	16,2	2 836 551	29 547	16,6	104.2
20,000 through 49,999 inhabitants	559 939	22,1	3 853 521	41 088	23,1	106.6
50,000 or more inhabitants	946 361	37,3	6 466 725	61 401	34,6	94.9
Healthcare region						
North	242 495	9,6	1 668 892	18 101	10,2	108.5
Central	344 185	13,6	2 371 607	25 920	14,6	109.3
West	513 298	20,2	3 525 557	31 670	17,8	89.8
South-East	1 435 235	56,6	9 843 137	101 972	57,4	103.6

a Including people born in Norway of immigrant parents.
b Follow-up time from January 1, 2008, to December 31, 2014.
c Number of eligible cases included in the study.
d Number of new cases per 10,000 person-years at risk.

Table 2
Injury incidence rate ratios (IRR) for acute hospitalization by socioeconomic status in the Norwegian population (25–64 years of age) during 2008–2014.

	Residents (N = 2.535.213)		Acute hospitalization (N = 177.663)			
Socioeconomic Status	No.	No. Person-y at Risk[a]	No. Events	Incidence Rate[b]	Adj. IRR (95% CI)[c]	Adj. IRR (95% CI)[d]
5th quintile (high)	420 243	2 912 490	24 400	83.8	1.00 (ref)	1.00 (ref)
4th quintile	403 488	2 798 365	25 628	91.6	1.13 (1.11 - 1.14)	1.11 (1.09 - 1.13)
3rd quintile	626 073	4 335 635	42 297	97.6	1.23 (1.21 - 1.25)	1.21 (1.19 - 1.22)
2nd quintile	532 333	3 663 736	38 245	104.4	1.34 (1.32 - 1.36)	1.30 (1.28 - 1.32)
1st quintile (low)	553 076	3 698 966	47 093	127.3	1.63 (1.61 - 1.66)	1.57 (1.55 - 1.60)

a Follow-up time from January 1, 2008, to December 31, 2014.
b Crude number of new cases per 10,000 person-years at risk.
c Adjusted for sex and age group.
d Adjusted for sex, age group, marital status, ethnicity, municipality population size and healthcare region of residence.

Table 3
Incidence rate ratios for acute hospitalization by socioeconomic status and severity measured as threat-to-life using the International Classification of Diseases-based Injury Severity Score (ICISS).

Model	Socioeconomic Status	No. Person-y at Risk[a]	No. Events	Incidence Rate[b]	Adj. IRR (95% CI)[c]	Adj. IRR (95% CI)[d]
Model 1: injuries with high threat to life	5th quintile (high)	2 746 860	561	2.0	1.00 (ref)	1.00 (ref)
	4th quintile	2 624 168	542	2.1	1.11 (0.98 - 1.25)	1.11 (0.99 - 1.25)
	3rd quintile	4 048 338	877	2.2	1.26 (1.13 - 1.40)	1.26 (1.13 - 1.40)
	2nd quintile	3 405 960	869	2.6	1.56 (1.40 - 1.74)	1.52 (1.36 - 1.69)
	1st quintile (low)	3 389 771	1 337	3.9	2.39 (2.15 - 2.65)	2.25 (2.03 - 2.51)
Model 2: injuries with lower threat to life	5th quintile (high)	2 908 718	23 839	82.0	1.00 (ref)	1.00 (ref)
	4th quintile	2 794 725	25 086	89.8	1.13 (1.11 - 1.15)	1.11 (1.09 - 1.13)
	3rd quintile	4 329 753	41 420	95.7	1.23 (1.21 - 1.25)	1.20 (1.19 - 1.22)
	2nd quintile	3 658 037	37 376	102.2	1.33 (1.31 - 1.36)	1.30 (1.28 - 1.32)
	1st quintile (low)	3 690 596	45 756	124.0	1.62 (1.59 - 1.64)	1.56 (1.54 - 1.59)

a Follow-up time from January 1, 2008, to December 31, 2014.
b Crude number of new cases per 10,000 person-years at risk.
c Adjusted for sex and age group.
d Adjusted for sex, age group, marital status, ethnicity, municipality population size and healthcare region of residence.

Table 4
Incidence rate ratios for acute hospitalization by socioeconomic status and severity measured probability of long-term disability using disability weights from the Validating and Improving Injury Burden Estimates Study (Injury-VIBES) project.

Model	Socioeconomic Status	No. Person-y at Risk[a]	No. Events	Incidence Rate[b]	Adj. IRR (95% CI)[c]	Adj. IRR (95% CI)[d]
Model 3: injuries with high probability of long-term disability	5th quintile (high)	2 775 559	4 698	16.9	1.00 (ref)	1.00 (ref)
	4th quintile	2 653 837	4 822	18.2	1.15 (1.10 - 1.19)	1.13 (1.10 - 1.17)
	3rd quintile	4 095 543	7 701	18.8	1.25 (1.20 - 1.29)	1.21 (1.20 - 1.25)
	2nd quintile	3 451 988	7 584	22.0	1.45 (1.40 - 1.51)	1.40 (1.40 - 1.45)
	1st quintile (low)	3 459 297	11 768	34.0	2.09 (2.02 - 2.17)	1.99 (1.92 - 2.07)
Model 4: injuries with medium probability of long-term disability	5th quintile (high)	2 833 468	13 014	45.9	1.00 (ref)	1.00 (ref)
	4th quintile	2 716 533	13 832	50.9	1.14 (1.11 - 1.16)	1.13 (1.10 - 1.15)
	3rd quintile	4 204 290	23 341	55.5	1.27 (1.24 - 1.30)	1.25 (1.22 - 1.27)
	2nd quintile	3 547 298	21 318	60.1	1.41 (1.38 - 1.44)	1.37 (1.34 - 1.40)
	1st quintile (low)	3 557 581	26 055	73.2	1.76 (1.73 - 1.80)	1.70 (1.66 - 1.73)
Model 5: injuries with low probability of long-term disability	5th quintile (high)	2 789 641	6 688	24.0	1.00 (ref)	1.00 (ref)
	4th quintile	2 669 051	6 974	26.1	1.11 (1.07 - 1.14)	1.10 (1.06 - 1.13)
	3rd quintile	4 120 715	11 255	27.3	1.17 (1.14 - 1.21)	1.15 (1.12 - 1.19)
	2nd quintile	3 464 972	9 343	27.0	1.17 (1.13 - 1.21)	1.15 (1.11 - 1.18)
	1st quintile (low)	3 444 891	9 270	26.9	1.17 (1.13 - 1.21)	1.15 (1.11 - 1.19)

a Follow-up time from January 1, 2008, to December 31, 2014.
b Crude number of new cases per 10,000 person-years at risk.
c Adjusted for sex and age group.
d Adjusted for sex, age group, marital status, ethnicity, municipality population size and healthcare region of residence.

long-term disability using the upper quintile of disability weight-scores as cut-off (Model 3). Compared with people in the highest SES category, all other SES categories were associated with an increased risk of injuries of the corresponding severity level, with twice the increase in risk for people in the lowest SES category (aIRR=1.99 95% CI: 1.92, 2.07). For patients with medium threat of long-term disability, defined as injuries with disability weight-scores within the second through the fourth quintiles (Model 4, $N = 97{,}560$), those in the lowest SES category had a 70% increased risk compared to people with the highest SES (aIRR=1.70 95% CI: 1.66, 1.73). The patients with the lowest threat of long-term disability included people with scores in the lowest quintile of disability weight-scores (Model 5, $N = 43{,}530$). For these patients, the increase in risk with decreasing SES was less pronounced and did not increase further for SES quintiles lower than 3. We found an estimated 15% increase in risk for people in the three lowest SES quintiles compared to people in the highest SES quintile (aIRR=1.15 95% CI: 1.11, 1.19 for Q1 vs. Q5) (Table 4).

Additional sensitivity analyses involved comparing SES-calculated at baseline to SES-calculated at end of follow-up using year of censoring. We identified three groups: people with no change in their SES-score (22,7%), people with decreased SES-score (25,5%), and people with increased SES-score (51,8%). The trend across these groups were similar to the main analysis. However, the gradient in risk was steepest for people with no change in their SES-score (see Figure 1 in the Supplement). A total of 3,7 percent had acquired a higher educational level at the end of follow-up. Furthermore, 51,7 percent had changed to a higher occupational category, while 39,6 percent remained in the same occupational category during follow-up. A total of 34,4 percent changed income quartile, while 37,7 percent remained unchanged. Thus, the shift in SES-scores during the follow-up was primarily caused by changes in occupation and income.

Discussion

Our nationwide follow-up study of the entire Norwegian population aged 25–64 shows a consistent pattern between injury morbidity and SES during 2008 through 2014. Overall, we found that people with lower SES had an increased risk of hospitalization due to injury, compared with people in the highest SES category. Furthermore, the increased risk at lower SES was more pronounced for injuries of high severity than for injuries of low severity, both when assessing severity as threat-to-life using ICISS and as threat of long-term disability using disability weights from the Injury-VIBES project. These findings were also robust for adjustment of known confounders and to changes in SES during the follow-up period.

While consistent with much literature on the association between SES and injury morbidity rates [8,23–26], our findings differ from some studies in the US showing either no gradient [19] or increased injury incidence with higher SES [28]. In these studies, it was suggested that people with lower SES could be less likely to seek injury treatment due to possible expenses or difficulties in reaching healthcare facilities. Our study used data from Norway, a country with universal healthcare and a welfare system which should, ideally, counteract economic differences in seeking medical treatment. Thus, it is less likely that our results were biased by a direct effect of SES on seeking medical treatment. The observed injury risk was lower for immigrants compared to the host population. Other studies have reported similar findings, and a discussion of potential reasons is provided in a recent paper [47].

In accordance with other studies [19,29,30,31], our results provide further documentation for the claim that socioeconomic differences in injury risk vary by injury severity, with the steepest gradient observed for injuries of high severity. While this study can only speculate as to why people with low SES seem to be disproportionally affected by the most severe injuries, it seems plausible to tie this finding to differences in risk profile. For instance, lower SES groups are more likely to be driving older and less safe vehicles [48], putting them at greater risk of traffic-related high-energy trauma (e.g., traumatic brain injury). Likewise, there are reports of differences in the usage of safety equipment by SES, for instance in the use of seatbelts [49] and other everyday products [50]. People with low SES also experience more workplace hazards, increasing the risk of potentially severe injuries like fall from heights (e.g., in construction) or traumatic amputation (e.g., when operating machinery) [51]. Thus, the social patterning of injuries per se could be influenced by differences in risk exposure among different social groups or through differential susceptibility on the individual level due to how social background predisposes to certain risks based on individual resources such as knowledge and finances [52], type of occupation [53] or psychopathological differences due to SES [54].

Regardless of the mechanisms that mediate SES and injury severity, a novel feature of this study is that our findings applied to two different measures of severity (i.e., both immediate threat-to-life and threat of long-term disability). While these aspects of severity often will overlap (many life-threatening injuries also result in permanent disability), they can sometimes diverge (e.g., patients with critical injuries to internal organs may recover fully if optimal trauma care is delivered). This finding suggests that the association between SES and injury severity is robust and generalizable to different dimensions of severity.

Strengths and limitations of the study

Notable strengths of this study include the use of multiple measures of SES (education, income, and occupation) and the population-based design covering the total population in Norway within our defined age span, with reliable follow-up based on linkage of individual-level data in mandatory (and thus virtually complete) national registries. In addition, both ICISS scores and the Injury-VIBES disability weights provide valid and accurate estimation of the severity of injury [34,38]. As the Norwegian healthcare system is founded on the principle of free and equal access to services, available to all residents regardless of social and economic status, our results are also less biased by potential differences in access to care by SES compared to countries where healthcare is organized and funded differently.

One possible limitation is that people with higher SES may have used private health services to a larger degree than people with lower SES, thus resulting in an apparent overestimation of difference by SES. However, treatment at private health facilities constitutes a small fraction of all hospitalizations due to injuries (reported to be approximately 0,5% in 2014) [55]. Thus, it is unlikely that the results would have changed substantially had we included private health services.

Finally, some types of injury are rare, even in nationwide studies with several years of follow-up. This adds uncertainty to estimates of the severity of injury. However, previous studies have shown substantial similarities between other high-income countries in terms of ICISS [56]. Furthermore, we found that the results were consistent for the two injury severity measures used in our study, even with a modest positive correlation.

Implications and potential extensions

In general terms, by showing that low SES increases the risk of injury, the results of this study suggest that socioeconomic circumstances should be treated as a target for local and national health strategies, health risk surveillance, interventions, and policy. Furthermore, our findings provide support for the claim that prevention efforts should be aimed at the most severe injuries, as such efforts will likely have the added benefit of reducing socioeconomic differences in injury risk. More in-depth analyses on the contribution of SES on specific types of injuries, as well as exploring differences in risk exposure, may give further clues to understand the causal mechanisms underlying social inequalities, thereby providing us with better tools to reduce differences in injury incidence by SES.

Conclusions

This population-based study provides an assessment of the magnitude and burden of the socioeconomic distribution of injuries and injury severity in acute hospitalizations. The results can guide future research on the causal mechanism of social inequalities per se, and by injury type, thus provide a better understanding of how to intervene and reduce these inequalities. Targeting of preventive measures is needed to reduce the magnitude and burden of the socioeconomic distribution of injuries and injury severity in acute hospitalizations.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Ethics approval and consent to participate

The Regional Committee for Medical and Health Research Ethics in Norway (REC approval number: 2014/1945) approved the study in advance. Informed consent was not obtained from the individual participants included in the study, as data were obtained from nationwide health registries to which reporting is mandatory.

Consent for publication

Not applicable.

Disclaimer

Data from the Norwegian Patient Registry have been used in this publication. The interpretation and reporting of these data are the sole responsibility of the authors, and no endorsement by the Norwegian Patient Registry is intended or should be inferred.

Supplementary materials

The current study is part of a research project at the Norwegian Institute of Public Health. The datasets generated and analysed during this study are not publicly available due to data protection stipulations but can be made available on a remote access platform to researchers who become project members. Alternatively, these data can be reconstructed anew by applying to each registry.

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.injury.2022.03.039.

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