Eur J Epidemiol (2015) 30:151–157
DOI 10.1007/s10654-014-9969-1

INJURY EPIDEMIOLOGY

Socio-economic status and co-morbidity as risk factors for trauma

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Received: 10 May 2014 / Accepted: 25 October 2014 / Published online: 7 November 2014

Abstract Clinical experience and previous studies indicate that low socioeconomic positions are overrepresented in trauma populations. The reason for this social variation in injury risk is likely to be multifactorial. Both individual and environmental sources of explanation are plausible to contribute. We investigated the impact of the influence of socioeconomic factors and co-morbidity on the risk of becoming a trauma victim in a case–control study including 7,382 trauma patients matched in a one to five ratio with controls matched by age-, gender- and municipality from a level 1 trauma centre. Data from the trauma cohort were linked to national registries. Associations between socioeconomic factors and co-morbidity were estimated by conditional logistic regression. The trauma patients had been treated for psychiatric, substance abuse and somatic diagnoses to a higher extent than the controls. In the conditional logistic regression analysis a low level of education and income as well as co-morbidity (divided into psychiatric, substance abuse and somatic diagnoses) were all independent risk factors for trauma. Analysing patients with an injury severity score >15 separately did not alter the results, except for somatic diagnoses not being a risk factor. Recent treatment for substance abuse significantly increased the risk for trauma. Low level of education and income as well as psychiatric, substance abuse and somatic co-morbidity were all independent risk factors for trauma. Active substance abuse strongly influenced the risk for trauma and had a time dependent pattern. These insights can facilitate future implementation of injury prevention strategies tailored to specific risk groups.

Keywords Trauma · Outcome · Co-morbidity · Gender · Case–control

Abbreviations

AIS	Abbreviated injury scale
CI	Confidence intervals
ICD-10	International classification of diseases
IQR	Interquartile ranges
ISS	Injury severity score
LISA	The Longitudinal integration database for health insurance and labour market studies
NBHW	Swedish national board of health and welfare
SES	Socioeconomic status
WHO	World health organization

Introduction

Throughout history severe trauma has been a major contributor to the loss of human life. With the development of modern trauma care, outcome has improved significantly over the last decades. Despite this progress trauma remains a common cause of death in younger persons. From a global perspective trauma causes a cumulative burden of disease in the range of cancer and is closely associated with significant morbidity and high societal costs. Thus, the importance of injury prevention cannot be stressed enough

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and insight in factors associated with trauma can facilitate strategies tailored to specific risk groups.

Clinical experience and previous studies indicate that low socioeconomic positions are overrepresented in trauma populations [1, 2]. The reason for this social variation in injury risk is likely to be multifactorial. Both individual and environmental sources of explanation are plausible to contribute [3]. To what extent certain co-morbid conditions frequently noted with disparities in socio-economy are contributing is not full elucidated. Co-morbid conditions and their influence on post-injury outcome are well described in trauma populations but to a lesser extent the association between co-morbidity and the risk for trauma [4–6]. Psychiatric disorders and substance abuse (alcohol or drugs) have been shown to increase the risk for mortality and morbidity after trauma. How these conditions influence the risk of becoming a trauma victim is not completely known [7, 8]. Socioeconomic positions and co-morbidity are likely to be related, however, very few studies have included both parameters in the analysis when assessing the risk of becoming a trauma victim.

The aim of this case–control study was to investigate the influence of both socioeconomic factors and co-morbidity on the risk of trauma. For this purpose we used the Trauma Registry in combination with national health registries including data on all health care episodes on a patient specific level.

Methods

Setting and study population

In this case–control study patients 15 years or older found in the Trauma Registry at the Karolinska University Hospital Stockholm, Sweden, with a first trauma admission between January 2005 and December 2010 were eligible for inclusion as cases. All patients admitted with trauma team activation, as well as patients admitted without trauma team activation but found to have an injury severity score (ISS) >9, are consecutively included in the Trauma Registry at the Karolinska University Hospital, Stockholm, Sweden. Our institution is the only referral centre for severe trauma in the entire Stockholm region and the catchment area covers more than two million inhabitants. Patients classified as dead after brief resuscitation following admittance are also included. Isolated fractures of the upper or lower extremity, drowning, chronic subdural hematoma, burn injury, and hypothermia without concomitant trauma are not included in the registry. Patients with an ISS above 15 were considered severely injured. After exclusion of patients who had an invalid personal identity number (n = 359), 7,382 trauma cases were included in the analysis. Eligible controls were Swedish residents not found in the Trauma Registry. A random sample from the general population of 36,910 age, gender and municipality matched controls were extracted from the register of total population. One hundred and fifty controls dying before the trauma date for their respective case were omitted from the study yielding at total of 36,760 controls.

National registries

All citizens in Sweden have a unique 12-digit personal identity number, facilitating linkage between different national registries [9]. The Swedish national patient register managed by the Swedish Board of Health and Welfare (NBHW) covers all information regarding public in-patient and out-patient visits. Each care episode corresponds to one record in the registry and contains the personal identity number, hospital/clinic, dates of admission and discharge, and International Classification of Diseases (ICD)-diagnoses of which one is the principal [10]. No trauma patients are treated in the private sector in Sweden. The cause of death register is managed by the centre for epidemiology at the NBHW and records cause and time of death for all deceased Swedish residents. Statistics Sweden is responsible for official statistics regarding the national census and manages the register of total population.

Exposure ascertainment (socioeconomic status and co-morbidity)

Education and income were used as proxies for socioeconomic status (SES). Information on education for cases and controls was extracted from the Register of Total Population. The level of education was classified into low, medium and high, corresponding to ≤9, 10–12 and >12 years (last category equalling university level) of schooling respectively. Information on income was retrieved from the longitudinal integration database for health insurance and labour market studies (LISA by Swedish acronym) at Statistics Sweden. The median income was based on statistics for Swedish citizens in working age (20–64 years) during the time of the study. Income was classified into three groups: low, medium, and high. Low income was defined as an income below 50 % of the median income the year preceding the trauma. High income was defined as an income more than 200 % of the median at the year before trauma. Missing data were noted only for socioeconomics and was found to be below ten percent. A total of 679 (9.2 %) cases and 2,829 (7.7 %) controls for education, 345 (4.7 %) cases and 1,541 (4.2 %) controls for income were noted respectively.

Co-morbidity was assessed for cases and controls by the prevalence of selected diagnoses 8 years prior the trauma

admission date. Three groups were analysed. Somatic pre-existing medical conditions were defined as the presence of at least one ICD-10 code based on the Charlson co-morbidity index as adapted by Gabbe et al. [11]. Psychiatric and substance abuse diagnoses were defined as the presence of a diagnosis in ICD group F20–F99 and F10–F19 respectively. The three groups were also analysed for time dependency i.e. the latest treatment within or before 6 months of injury.

Ethical approval

This study was approved by the regional ethical review board in Stockholm, Sweden.

Statistical analyses

Characteristics of cases and controls were presented using frequencies and percentages for categorical variables and median with interquartile range (IQR) for continuous variables. Crude comparisons of proportions were performed by Chi square test. Associations between trauma and education, income and co-morbidity were estimated by conditional logistic regression and expressed as odds ratios with corresponding 95 % confidence intervals. Co-morbidity (psychiatric, substance abuse and somatic diagnoses), levels of education and income were analysed for a univariate association. All variables that were statistically significant in the univariate model were included in the final multivariable regression model. Odds ratios from unadjusted (univariate) and adjusted (multivariable) regression models are presented to express the likelihood of being a trauma victim.

All analyses were carried out for the whole study group as well as separately for patients with an ISS above 15. Statistical significance was defines as a double-sided $p < .05$. IBM SPSS Statistics 22 (SPSS Statistics IBM, Armonk, New York) was used for statistical analyses.

Results

The study population consisted of 7,382 trauma patients and 36,760 matched controls. Characteristics of the study population are shown in Tables 1 and 2. One-third were females and the median age was 39 years. Fewer trauma patients had achieved a university education compared with the controls, one-fifth compared to one-third. There was a higher proportion of individuals with low-income and co-morbidities among trauma patients, this relationship remained unchanged when the study population was restricted to individuals with an ISS-score of more than 15 ($p < .0001$ and $p < .0001$ respectively). Trauma patients had been treated for psychiatric, substance abuse and somatic diagnoses to a higher extent than the controls. A substance abuse diagnosis was nearly sixth times more common among the severely injured compared with controls (Tables 1 and 2).

Table 1 Characteristics of the study population (All patients)

	All	
	Trauma (n = 7,382)	Matched controls (n = 36,760)
Sex		
Female n (%)	2,297 (31.1)	11,436 (31.1)
Male n (%)	5,085 (68.9)	25,324 (68.9)
Age, years, median (IQR)	39 (25–55)	39 (25–55)
ISS, median (IQR)	5 (2–14)	
Level of education		
Low n (%)	2,120 (31.6)	7,932 (23.4)
Medium n (%)	3,049 (45.5)	14,592 (43.0)
High n (%)	1,534 (22.9)	11,407 (33.6)
Income		
Low n (%)	3,818 (54.3)	16,636 (47.2)
Medium n (%)	2,878 (40.9)	15,687 (44.5)
High n (%)	341 (4.8)	2,896 (8.2)
History of co-morbidity, count (%)	2,869 (38.9)	9,115 (24.8)
Co-morbidity		
Psychiatric diagnosis	989 (13.4)	2,017 (5.5)
Substance abuse diagnosis	1,029 (13.9)	1,053 (2.9)
Somatic diagnosis	1,805 (24.5)	7,142 (19.4)

Continuous parameters presented as median (inter quartile range, IQR). Categorical parameters presented as number (%). Injury severity score (ISS)

Severity and mechanisms of injury and its relation to socioeconomics are shown in Tables 3, 4 and Fig. 1. Approximately one quarter of the trauma patients had an ISS-score more than 15. The median ISS-score overall was five and in the severely injured group (ISS > 15) 24. A majority of the patients had traffic-related injuries and 28 % were associated with falls. The number of falls and self-inflicted injuries were higher among the severely injured patients (Table 3). The distribution pattern of injury mechanisms differed largely with the level of education and income (Table 4; Fig. 1). Low levels were commonly noted among victims of assault.

In the conditional logistic regression analysis of the total cohort, level of education, income and co-morbidity (divided into psychiatric, substance abuse and somatic diagnoses) were all independent risk factors for trauma (Table 5). When analysing the severely injured patients separately the results did not alter except for somatic diagnoses not being a risk factor (Table 5). In the severely

Table 2 Characteristics for study population

	ISS > 15	
	Trauma (n = 1,764)	Matched controls (n = 8,759)
Sex		
Female n (%)	450 (25.5)	2,223 (25.5)
Male n (%)	1,314 (74.5)	6,526 (74.5)
Age, years, median (IQR)	48 (29–63)	47 (29–63)
ISS, median (IQR)	24 (17–29)	
Level of education		
Low n (%)	470 (29.7)	1,900 (23.3)
Medium n (%)	748 (47.3)	3,506 (43.0)
High n (%)	365 (23.1)	2,745 (33.7)
Income		
Low n (%)	980 (57.4)	4,258 (50.0)
Medium n (%)	653 (38.2)	3,516 (41.3)
High n (%)	75 (4.4)	739 (8.7)
History of co-morbidity, count (%)	775 (43.9)	2,564 (29.3)
Co-morbidity		
Psychiatric diagnosis	214 (12.1)	439 (5.0)
Substance abuse diagnosis	308 (17.5)	239 (2.7)
Somatic diagnosis	512 (29.0)	2,167 (24.7)

(Patients with ISS > 15)

Continuous parameters presented as median (inter quartile range, IQR). Categorical parameters presented as number (%). Injury severity score (ISS)

Table 3 Mechanisms of injury

	All (n = 7,382)	ISS > 15 (n = 1,764)
Penetrating trauma, count (%)	468 (6.3)	87 (4.9)
Mechanism of injury, count (%)		
Traffic-related	3,926 (53.2)	716 (40.6)
Fall	2,087 (28,3)	706 (40.0)
Assault	829 (11.2)	157 (8.9)
Self–inflicted	267 (3.6)	118 (6.7)
Others	271 (3.7)	67 (3.8)

Categorical parameters presented as number (%). Injury severity score (ISS)

injured adjusted odds ratio for low level of education and income was 1.4 (95 % confidence interval 1.2–1.6) and 1.3 (1.1–1.7) respectively (Table 5). Substance abuse increased the risk for trauma more than three times in the severely injured.

In addition, we analysed the impact of recent (6 months prior to injury) treatment for co-morbid conditions (Fig. 2). A recent treatment for substance abuse or a somatic disorder significantly increased the risk of trauma.

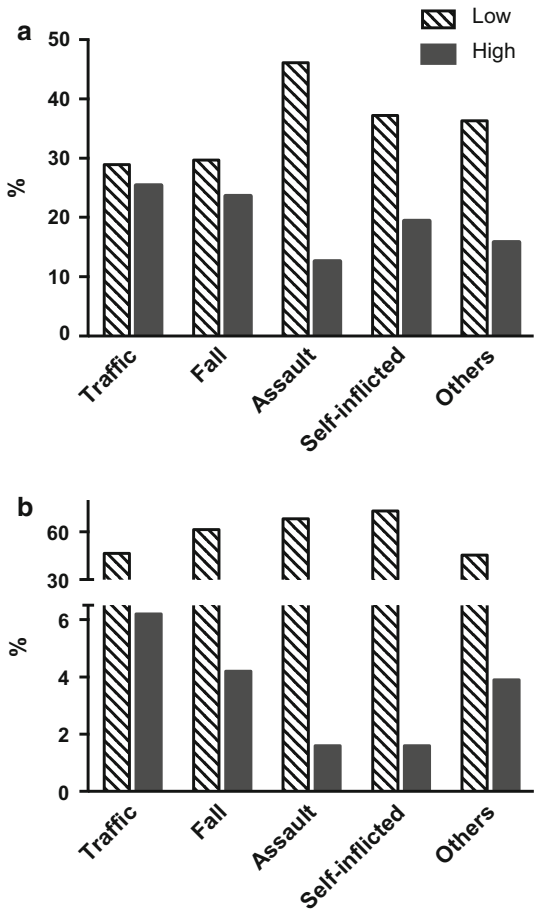

Fig. 1 Proportions of low and high levels of education (**a**) and income (**b**) in relation to mechanisms of injury. Striped bars represent low level and filled bars high level of education and income respectively. Distribution of proportions significantly different by Chi square test. $p < 0.001$ and $p < 0.001$ respectively

Discussion

In this case–control study of more than 7,000 trauma patients, including both socioeconomic position and co-morbidity in the analysis, we found that both entities independently influenced the risk of becoming a trauma victim. Low levels of income and education as well as psychiatric, substance abuse and somatic diagnoses were all independent risk factors for becoming a trauma victim. Our results also indicate that recent substance abuse significantly increases the risk for trauma.

The patient demographic characteristics in the current study was similar to previously described trauma cohorts with a high proportion of male gender, a dominance of traffic-related accidents and more than one-third of the cases with a history of co-morbidity [12, 13]. A majority of the patients had had a low income, defined as <50 % of the median national income. These proportions differ markedly from the general population in Sweden and may

Table 4 Proportions of levels of education (a) and income (b) for different mechanisms of injury

Level of education Mechanism of injury, count (%)	Low count (%)	Medium count (%)	High count (%)
a			
Traffic-related count (%)	1,038 (49.0)	1,644 (53.9)	914 (59.6)
Fall count (%)	552 (26.1)	868 (28.5)	439 (28.6)
Assault count (%)	352 (16.6)	316 (10.4)	96 (6.3)
Self–inflicted count (%)	90 (4.2)	105 (3.4)	47 (3.1)
Others count (%)	87 (4.1)	115 (3.8)	38 (2.5)
Level of income Mechanism of injury, count (%)	Low count (%)	Medium count (%)	High count (%)
b			
Traffic-related count (%)	1,725 (45.2)	1,745 (60.7)	228 (66.9)
Fall count (%)	1,245 (32.6)	698 (24.3)	86 (25.2)
Assault count (%)	542 (14.2)	240 (8.3)	13 (3.8)
Self–inflicted count (%)	189 (5.0)	65 (2.3)	4 (1.2)
Others count (%)	116 (3.0)	129 (4.5)	10 (2.9)

The level of education: low, medium and high corresponding to ≤9, 10–12 and >12 years of schooling respectively. Low income was defined as a income below 50 % of the median income the year preceding the trauma. High income was defined as an income more than 200 % of the median at the year before trauma

Table 5 Conditional logistic regression analysis, all patients and patients with ISS > 15

	Odds ratio (95 % CI)		Odds ratio (95 % CI)	
	All		ISS > 15	
	Unadjusted	Adjusted	Unadjusted	Adjusted
Level of education				
Low	1.8 (1.7–1.9)	1.5 (1.4–1.6)	1.7 (1.5–1.9)	1.4 (1.2–1.6)
Medium	1.5 (1.4–1.5)	1.3 (1.3–1.4)	1.5 (1.3–1.7)	1.3 (1.1–1.5)
High	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Income				
Low	1.8 (1.6–2.0)	1.2 (1.1–1.3)	2.0 (1.6–2.6)	1.3 (1.1–1.7)
Medium	1.5 (1.3–1.6)	1.2 (1.1–1.4)	1.7 (1.3–2.2)	1.4 (1.1–1.8)
High	1.0 (reference)	1.0 (reference)	1.0 (reference)	1.0 (reference)
Co-morbidity				
Psychiatric diagnosis	2.1 (2.0–2.3)	1.5 (1.4–1.6)	2.1 (1.8–2.4)	1.4 (1.2–1.6)
Substance abuse diagnosis	3.3 (3.1–3.5)	2.6 (2.4–2.8)	3.9 (3.4–4.4)	3.4 (3.0–4.0)
Somatic diagnosis	1.3 (1.2–1.3)	1.1 (1.1–1.2)	1.2 (1.1–1.3)	1.0 (0.9–1.1)

Data presented as odds ratios with 95 % confidence intervals (CI). Analysis of all patients and stratified for injury severity (ISS > 15)

partly be explained by a young study cohort with a low average level of education [14].

Different definitions of socioeconomic positions in previously published literature can lead to difficulties when comparing studies. Two of the most common ways to describe the socioeconomic position on an individual level are education and income [15]. Our ability to use general population data and the intention to use more than one modality of socio-economy in the model made us chose levels of education and income as descriptors of SES. The Swedish personal identity number provides a unique tool for linking data from the trauma registry to validated national health registries. This generated a robust data set of the trauma population (cases) together with matched controls, including information on income, level of education and pre-existing medical conditions [9].

The effects of socioeconomic differences on the risk of trauma as well as morbidity and mortality have been studied previously [16–18]. The relationship is well documented but the causality is far from clear. A recent WHO report describes that previous studies have usually been focused on specific injury mechanisms e.g. falls or road accidents and have not included injury severity as a variable [15]. In contrast, the current study includes severity of injury and is not limited to a certain mechanism.

Other authors have shown that SES as well as co-morbidity are risk factors for injury [17, 18]. Although well studied these entities have not been included and adjusted

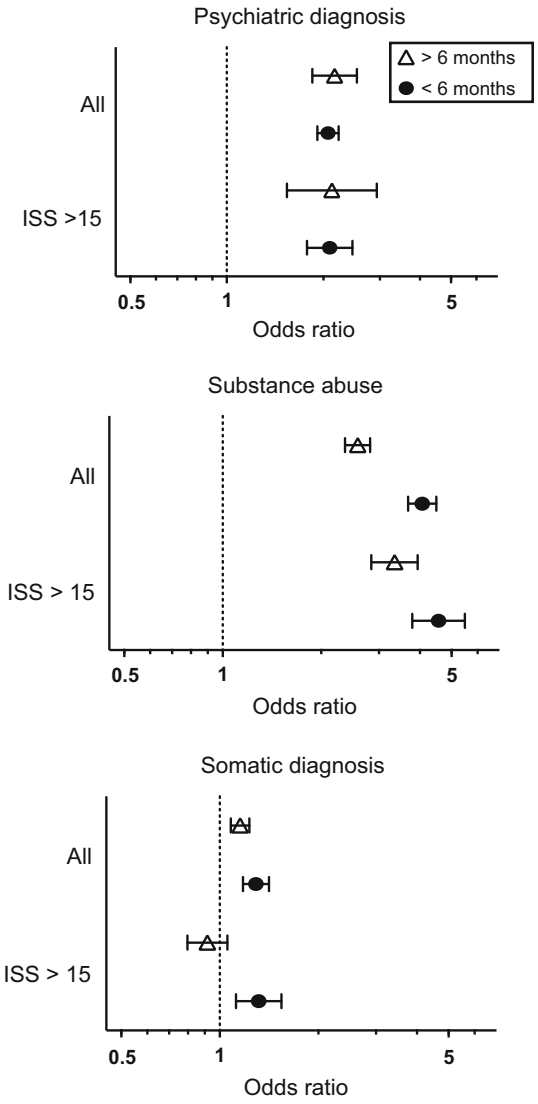

Fig. 2 Impact of treatment for a psychiatric, substance abuse or somatic disorder within 6 months on the risk of trauma. The figure displays how the odds ratio (95 % CI) for trauma is affected by having the most recent treatment within 6 months (*open triangles*) as compared with before 6 months (*closed circles*) of the time of injury for all and severely injured (ISS > 15) patients respectively. The analyses were adjusted for socioeconomic status

for in the same analysis previously. We showed that both parameters were independently associated with an increased risk of trauma. Clinical experience and previous studies suggest that a significant proportion of trauma patients are suffering from psychiatric disorders and/or substance abuse problems [19]. In the current study, data on co-morbidity 8 years preceding the trauma was retrieved from the Swedish national patient register. The data was divided into three groups; somatic co-morbidity based on Charlson index as adapted by Gabbe et al. [11], psychiatric disorders and substance abuse. The overall prevalence of co-morbidity among the trauma patients by these definitions was 39 %, a figure in line with several other studies [13, 20]. We could demonstrate that low levels of education and income are significant risk factors for trauma, even when adjusting for somatic, psychiatric and substance abuse diagnoses. We could also show that co-morbidity is a strong independent risk factor in a time-dependent manner, where the risk of trauma is greatly increased if you have been treated for a substance abuse within 6 months before the trauma. This finding suggests a strong impact of active drug abuse. Notably, recent treatment for a somatic disorder significantly increased the risk of severe trauma. A finding not seen for patients with a somatic diagnosis not treated for the last 6 months. This may reflect that patients with a new or active somatic disease are more prone to injury. Few studies have addressed this temporal relationship. Psychiatric diagnoses were a strong risk factor for trauma, regardless if treated recently or not. Symptoms related to psychiatric disorders, risk behaviour and side effect of medication are some of the plausible contributors to this finding.

Different factors may explain the association between SES and the risk of trauma and outcome. One is that certain socioeconomic positions are exposed to increased risks in life e.g. hazards at home and in the neighbourhood. Another theory is that socio-economy affects the vulnerability, which can be described as the ability to prevent health problems and take various precautionary measures. This could explain the distribution of mechanisms of injury in different socioeconomic positions seen in the current study where assault and self-inflicted injury were uncommon in patients with high SES. A third explanation is that the consequences of illness or injury differ according to SES, e.g. adherence and access to medical treatment and technology [3, 16, 21, 22].

Possible study limitations are associated with the registry-based study design. The study is strengthened by the use of the well-validated national registries and the adjusted model. Missing data in the national registries is considered a minor issue since health providers must report treated patients to the registries in order to receive funding [10]. Are our results applicable to other trauma populations? Our study is a single centre study that can be considered to reduce the generalizability, nevertheless the trauma cohorts in this study is largely similar to those described in other studies. There was a dominance of male gender and a majority of younger patients with a mean age of approximately 40 years and one-third of the patients exhibiting some pre-existing medical condition. Thus, the demographic characteristic is much in line with several other trauma studies [20, 23–25].

Conclusion

In this case–control study we investigated the influence of socioeconomic status and co-morbidity on the risk of

becoming a trauma victim. A low socioeconomic position remained an independent risk factor also after adjustment for co-morbidity. Low levels of education and income as well as psychiatric, substance abuse and somatic co-morbidity were all independent risk factors for trauma. Active substance abuse had a strong influence on the relative risk. These insights can facilitate implementation of injury prevention strategies tailored to specific risk groups.

Acknowledgments We are sincerely grateful to our trauma registry nurses Lisbeth Bergendal, Lena Jansson and Katarina Ramsberg-Enegren and Tina Friberg for their invaluable work with the trauma registry. We also thank Dr Timothy Baker for providing linguistic expertise. This study was supported by the Laerdal Foundation, the Magn Bergvall Foundation, the LPS Medical Foundation, the Cancer and Traffic Injury Fund, The Swedish Carnegie Hero Funds, Funds from Karolinska Institutet and the Swedish Society of Medicine. Financial support was also provided through the regional agreement on medical and clinical research (ALF) between Stockholm County Council and Karolinska Institutet.

Conflict of interest The authors declare that they have no conflict of interest.

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