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Pediatric traumas and neighborhood socioeconomic characteristics: A population based study☆

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ABSTRACT

Background: Identifying pediatric populations at risk for traumas would enable development of emergency medical services and emergency departments for children. Elucidation of the nature of socioeconomic differences in the incidence of pediatric out-of-hospital emergencies is needed to overcome inequities in child health.
Methods: We retrieved all ambulance contacts during 17.12.2014–16.12.2018 involving children (0–15 years) in Helsinki, Finland and separated traumatic and nontraumatic emergencies. We compared the incidences of these emergencies in the pediatric population with socioeconomic markers of the scene of the emergency and of the residential area of the child.
Results: Of 11,742 ambulance contacts involving children 4113 (35.0%) were traumatic. Traumatic emergencies occurred more often in neighborhoods with lower median income/household ($P = 0.043$) and were more common in children living in areas with lower median income/inhabitant ($P = 0.001$), higher unemployment ($P < 0.001$), and lower education ($P < 0.001$). The associations were weaker for traumatic than nontraumatic emergencies. Higher proportion of a pediatric population in a residential area ($P = 0.005$) had a protective effect. Exclusion of clinically unnecessary ambulance responses did not change the results.
Conclusion: Traumatic emergencies in children are more common in areas with lower socioeconomic status. The possible protective effect of urban planning merits further studies.
Type of study: Prognostic.
Level of evidence: II.

Injuries and violence are leading causes of death in children globally [1–3]. The burden of injury is greatest among children living in poorer countries, and within all countries injuries are more common in children from low-income families [1,3].

As the most beneficial approach to traumas in children is their prevention, World Health Organization (WHO), Unicef and national organizations and authorities have launched programs to prevent child injury [1,3,4]. Socioeconomic factors previously associated with injury risk in children include economic, social, housing, parental and family-related factors, i.e. family income, maternal education, and number of household members [1,5–7]. Although the risks behind injuries may be evident, preventing them in practice is not easy. Clearly, if the risks are not evenly distributed, universal programs may not be effective; instead, preventive measures should be designed and targeted for those most in need. Preventive actions should be allocated and targeted considering the socioeconomic, demographic, and urban structures underlying the risks.

To target preventive actions as well as emergency department (ED) and emergency medical services (EMS) resources, easily accessible indicators of areas and populations at higher risk are needed also in high-income countries. A few recent studies have addressed the association between childhood injuries and socioeconomic status in developed countries, but most of these are based on individual data [7–10]. For public health promotion and administrative purposes however, it is more important to identify risk populations than individuals at increased risk.

We have previously reported a statistically and clinically significant association between the incidence of EMS-treated out-of-hospital emergencies in children and a lower socioeconomic status of the neighborhood [11]. Owing to small cohort size, we were unable to state

Abbreviations: CI, Confidence interval; ED, Emergency department; EMS, Emergency medical services; ERC, Emergency response center; IQR, Interquartile range; RR, Risk ratio; WHO, World Health Organization.

☆ Declarations of interest: None.

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whether this association was consistent for both medical complaints and injuries. In order to target interventions, clarification of this association is needed; injury prevention requires different approaches than procedures required to overcome health differences in medical issues. If the incidence of injuries is increased in disadvantaged residential areas, children especially in these areas could benefit from injury prevention and community planning campaigns that have been shown to be effective in general [1,6,12].

Thus, we decided to study in a larger, population-based approach whether the incidence of pediatric EMS-treated traumatic emergencies in a neighborhood also follows a socioeconomically stratified pattern. The aim of this study was to find easily accessible socioeconomic factors that could be used for the design of EMS and ED services, for urban planning, and for targeting preventive measures, the goal, ultimately, being a decrease in socioeconomic differences in child health.

1. Material and methods

We conducted a population-based retrospective register study that included all out-of-hospital EMS responses to traumatic emergencies in a pediatric population (0–15 years) in Helsinki, Finland during a four-year period. We compared the geographical distribution of the traumatic emergencies with the geographical distribution of certain easily accessible socioeconomic and demographic parameters describing: 1) age distribution 2) education level 3) unemployment level 4) proportion of the population with immigrant background and 5) income level of residential areas.

1.1. Study area and population

Finland (5,503,000 inhabitants in 2017) is a Nordic welfare state with a publicly financed universal healthcare system. Helsinki is the capital and the largest city of Finland, with a total population of 643,000 and a population of 0–15-year-olds of 95,300 in 2017. The city area comprises both urban and suburban environments as well as the seacoast. There were approximately 2600 annual EMS contacts involving children aged 0–15 years between 2014 and 2016 [13].

The geographical area of Helsinki city is divided into 84 areas defined by different postal codes. This areal division is used for administrative purposes, as e.g. socioeconomic and demographic data are derived and expressed in relation to postal codes. The characteristics of each area are presented in Supplementary Table 1.

1.2. Organization of emergency medical services

All emergency calls from the study area are dialed to the same number (112). A professional emergency response center (ERC) operator categorizes the leading complaint or the mechanism of the trauma to form a dispatch code and determines a priority class from A to D according to a formal national questionnaire protocol. Ambulances are then dispatched with the combination of dispatch code and priority class. All calls do not result in the activation of EMS to the scene. When appropriate, the ERC operator may advise the caller to seek help from another source.

In Helsinki, all out-of-hospital emergencies are responded to by a single EMS provider consisting of 18 ambulances and a medical supervisor unit staffed by emergency medical technicians and paramedics as well as a mobile intensive care unit staffed by an emergency medical physician in addition to paramedics.

Not all patients encountered by EMS are transported to hospital by ambulance in Finland [13,14]. After examination and possible treatment, the ambulance personnel may decide that ambulance transport is not required. The nontransport decision and the information given to the patient or to the caregivers are documented in the electronic EMS patient record system, thus being easily traceable afterwards. The reason for a nontransport decision is classified by one of the nontransport codes. A nontransport decision does not automatically refer to an inappropriate EMS contact. In Finland, the ambulance personnel can treat many conditions either independently or after consultation with a physician. The electronic EMS patient record system (MerlotMedi, CGI Suomi Oy) includes an on-line consultation tool with i.e. high-resolution photographs. Thus, all patients not transported to ED by ambulance have been evaluated and informed on how to monitor and treat their condition, and whether or when to visit healthcare services by other means of transport. The EMS contact may also have included a remote consultation with a physician, comparable to a short ED visit. Still, the proportion of EMS contacts leading to nontransport with the notation “no need for treatment or transport” may reflect inappropriate use of EMS for nonurgent conditions, referred to as “clinically unnecessary” EMS responses to some extent [15].

The cost of the out-of-hospital evaluation and transport by EMS is small to the patient (16€), comparable to a short taxi ride. No payment or health insurance is required prior to or during the treatment or transport. Thus, all children have equal access to EMS in cases of emergency regardless of the socioeconomic status of the family.

1.3. Data collection

We retrieved data concerning out-of-hospital emergencies in the pediatric population responded to by the Helsinki EMS from 17.12.2014 to 16.12.2018. We separated traumatic emergencies from nontraumatic emergencies by the dispatch and transport codes. The EMS responses were divided into postal code areas 1) by the scene of the emergency (coordinates created during the dispatch process) and 2) by the residential area of the patient. The incidences were made proportional to the pediatric population as /1000 inhabitants aged 0–15 years/year. Of the 84 postal code areas one industrial area without permanent residents or EMS responses was excluded from analysis as not representing a residential area.

The data on dispatching and patient characteristics, including sex, age, and postal code of the residential area, and information on possible ambulance transport to ED were obtained from the electronic EMS patient record system (MerlotMedi, CGI Suomi Oy).

The effect of the age distribution of a residential area was examined by using the mean age of the whole population (years), proportion of the pediatric population (%), and the proportion of households with children (%). The proportion of adult (>18 years) population with an academic degree was used as an indicator of the level of education. The proportion of the population with a native language other than one of the national languages, Finnish or Swedish, was used as an indicator of presumed immigrant background.

Because we assumed that progressive taxation and income redistribution by state may be confounders, we used several points of view to examine the effect of income levels: 1) mean and median incomes per adult (>18 years) inhabitant, 2) mean and median incomes per household, and 3) purchasing power per inhabitant. Income data were corrected for inflation using inflation rates from Statistics Finland [16]. All studied variables are presented in Table 1.

Demographic and socioeconomic data were obtained for each year in 2014–2017 from Statistics Finland and used in comparisons as means of the four years [17]. The proportions of the population with native language other than Finnish or Swedish were available only for 2015–2017. As urban structures change slowly, the means or even numbers from a single year inside a study period reliably represent residential areas for a period of several years [5].

To explore whether the hypothesized association between socioeconomic status of the residential area and the incidence of traumatic out-of-hospital emergencies in children is because of inappropriate use of EMS for nonurgent conditions, we conducted the analyses also by excluding the cases in which the patient was evaluated to need neither transport nor treatment by ambulance personnel (nontransport code “no need for treatment or transport”, Fig. 1), as part of these contacts

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Table 1
Socioeconomic and demographic parameters and their indicators.

Parameter	Population	Median	IQR	Range
Mean age (years)	All population	40.3	39.0–41.9	28.0–44.3
Proportion of pediatric (0–15 years) population (%)	% of all population	15.5	12.3–18.3	4.5–30.3
Proportion of households with children (%)	% of all households	19.7	15.4–24.1	5.1–46.3
Proportion of population with academic degree (%)	% of >18-year-old population	54.4	45.3–64.5	20.3–87.8
Proportion of unemployed population (%)	% of >18-year-old population	9.9	7.6–12.8	3.2–19.2
Proportion of population with native language other than Finnish or Swedish[a] (%)	% of all population	9.3	7.5–15.7	1.3–31.2
Median income per inhabitant per year (1000€[b])	>18-year-olds	23.9	21.7–26.7	18.5–32.8
Mean income per inhabitant per year (1000€[b])	>18-year-olds	26.5	23.8–31.9	20.4–81.7
Median income per household per year (1000€[b])	All households	34.1	30.0–41.1	25.6–74.2
Mean income per household per year (1000€[b])	All households	42.4	36.5–56.3	30.7–152.3
Purchasing power per inhabitant per year (1000€[b])	All inhabitants	22.1	19.6–26.3	16.2–65.1

IQR = Interquartile range.
[a] National languages of the study area.
[b] Converted to monetary value in 2017.

probably represents "clinically unnecessary" EMS responses [15]. To explore whether the previously detected association between all out-of-hospital emergencies and socioeconomic parameters [11] is explained only by traumatic emergencies, we conducted the analyses also by the geographical distributions of nontraumatic emergencies.

1.4. Statistical analysis

The existence of an association between socioeconomic disadvantage and traumatic emergencies in the pediatric population has been demonstrated earlier [5,9,18], and as a retrospective study, our aim was not to find causalities between the socioeconomic factors, but easily accessible indicators for further studies and procedures. Thus, we choose simple univariate regression analysis for the primary statistical method since it gives the clinically most relevant answers to our study questions. The interrelations between the socioeconomic factors, which inevitably exist [5,18], were evaluated also with multivariate analyses.

The regression analyses were performed using negative binomial regression. The incidence risk ratios for the number of both out-of-hospital emergencies according to the scene of the emergency and according to the residential area of the patient were estimated for all income variables, mean age of the inhabitants, proportion of pediatric population, proportion of households with children, proportion of adult population with academic degree, proportion of the unemployed, and proportion of people with native language other than Finnish or Swedish. All models included an offset for the number of the pediatric population. Negative binomial regression model was chosen since the outcome was overdispersed in all cases. The overdispersion was tested using Applied Economics with R package. We chose the proportion of households with children, the median income per household, the proportion of adults with an academic degree, and the proportion of the population with native language other than the national languages to be included in the multivariate model for the incidence according to the scene of emergency. In the analyses based on the residential area of the patient, we chose median income per inhabitant instead of the median income per household since based on the univariate analyses, the income/inhabitant seemed to reflect better the impact of residential area and the income/household the impact of the scene. The analyses were performed using R V.3.6.3 (R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria) with the Modern Applied Statistics with S package (Venables, WN and Ripley, BD (2002), Fourth Edition, Springer, New York, ISBN 0-387-95457-0) using the MASS package (Venables, W. N. & Ripley, B. D. (2002) Modern Applied Statistics with S, Fourth Edition, Springer, New York, ISBN 0-387-95457-0).

The significance level of 0.05 was used for all statistical tests.

1.5. Ethics

This study was retrospective and register-based. No informed consent was required from patients or their caregivers. We did not contact the patients for study purposes and the study did not affect their treatment. We did not acquire personal or family data concerning

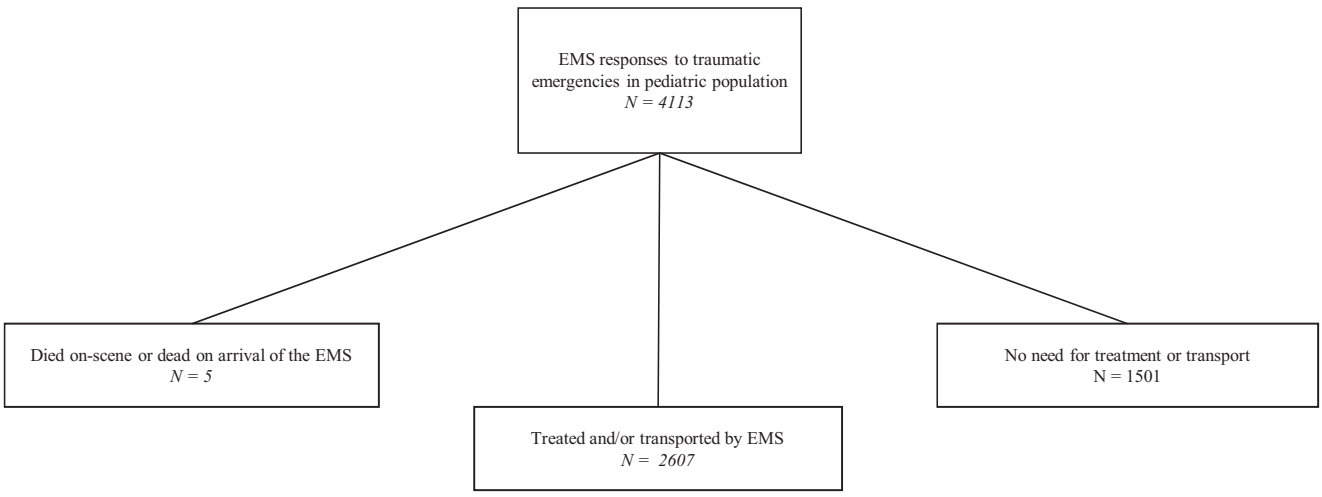

Fig. 1. Patient flow in traumatic out-of-hospital emergencies in the pediatric (0-15 years) population. EMS = emergency medical services.

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Table 2
The most frequent dispatch codes for emergency medical services contacts due to traumatic emergencies. An emergency response center operator forms the dispatch code by the mechanism of the trauma. The most frequent codes below include only unintentional injuries.

Dispatch code	*N* (%)
"Fall on the same level"	2012 (48.9%)
"Traffic accident"	474 (11.5%)
"Strike of a blunt object"	342 (8.3%)
"Crush"	336 (8.2%)
"Traumatic chocking"	264 (6.4%)

socioeconomic status of the patients. The institutional research committee of Helsinki University Hospital (§19, 17.12.2018) approved the study protocol.

2. Results

There were 277,914 out-of-hospital EMS contacts during the study period. Of these, 11,742 (4.2%) concerned patients aged 0–15 years. Of the emergencies in the pediatric population, 4113 (35.0%) were traumatic. The incidence of out-of-hospital EMS contacts involving children was 4.8/1000 inhabitants aged 0–15 years/year. The incidence of EMS contacts concerning traumatic emergencies in children was 1.7/1000/year and 11.1/1000 inhabitants aged 0–15 years/year, respectively.

Of the 4113 traumatic emergencies encountered by the EMS, five (0.01%) died at the scene or were dead on arrival of the ambulance. Altogether 1501 (36.5%) were judged not to require treatment or transport by ambulance. The patient flow is described in Fig. 1. Of the pediatric trauma patients, 2356 (57.3%) were boys, and in 62 cases the sex was not available retrospectively. The median age of the patients was 5.5 years (SD 5.43).

The most frequent dispatch codes describing the mechanisms of injuries are shown in Table 2. Traumatic emergencies caused by violence and crime are classified separately by the ERC operator, and accounted for 109 (2.7%) of the dispatch codes.

Of the 4113 traumatic emergencies the postal code of the scene was unavailable in 12 cases (0.3%), mainly for traffic accidents in highway areas without postal codes. The postal code of the residential area of the patient was not available in 39 cases, mainly because of incomplete personal details. In 520 cases, the residential area of the patient was located outside the study area. Of the 7629 nontraumatic emergencies, the postal code of the scene was not available in one case. In 551 cases, the residential area of the patient was located outside the study area, and in 69 cases the residential area was not available. The patient flow for analyses is illustrated in Fig. 2. The number of patients needing neither treatment nor transport was 1501 (36.5 %) among traumatic emergencies and 2 604 (34.1 %) among nontraumatic emergencies.

There was a linear relation between the incidences of all traumatic emergencies and traumatic emergencies after exclusion of those leading to nontransport with the code "no need for treatment or transport" (Fig. 3). Most of the studied residential areas also had similar proportions of traumatic emergencies leading to nontransport with the code "no need for treatment or transport" and all traumatic emergencies. When the few outliers where all or none of the EMS responses led to nontransport with the code "no need for treatment or transport" were excluded, the proportion of the included EMS responses was on average 64.3% (SD 8.8%) for the analyses according to the scene of the emergency and 63.0% (SD 9.9%) according to the residential area of the patient. The similarity between all traumatic emergencies and traumatic emergencies after exclusion of those with nontransport code "no need for treatment or transport" can also be seen in the univariate regression results (Table 3).

In univariate regression analyses, a higher proportion of 0–15-year old inhabitants, a higher proportion of households with children and a higher mean income per household were associated with a lower incidence of traumatic emergencies inside a residential area. When analyzed according to the residential area of the patient, a higher proportion of adult population with academic degree and a higher median income/inhabitant were associated with a lower, and a higher unemployment level and a higher proportion of population with presumed immigrant background with a higher incidence of traumatic emergencies among the pediatric population living inside a residential area. The results did not change when EMS responses leading to nontransport with the code "no need for treatment or transport" were excluded. A higher proportion of 0–15-year old inhabitants, a higher proportion of households with children, a higher proportion of adult population with academic degree, and higher incomes per household and inhabitant were associated with a lower incidence of nontraumatic emergencies inside a residential area, while a higher unemployment

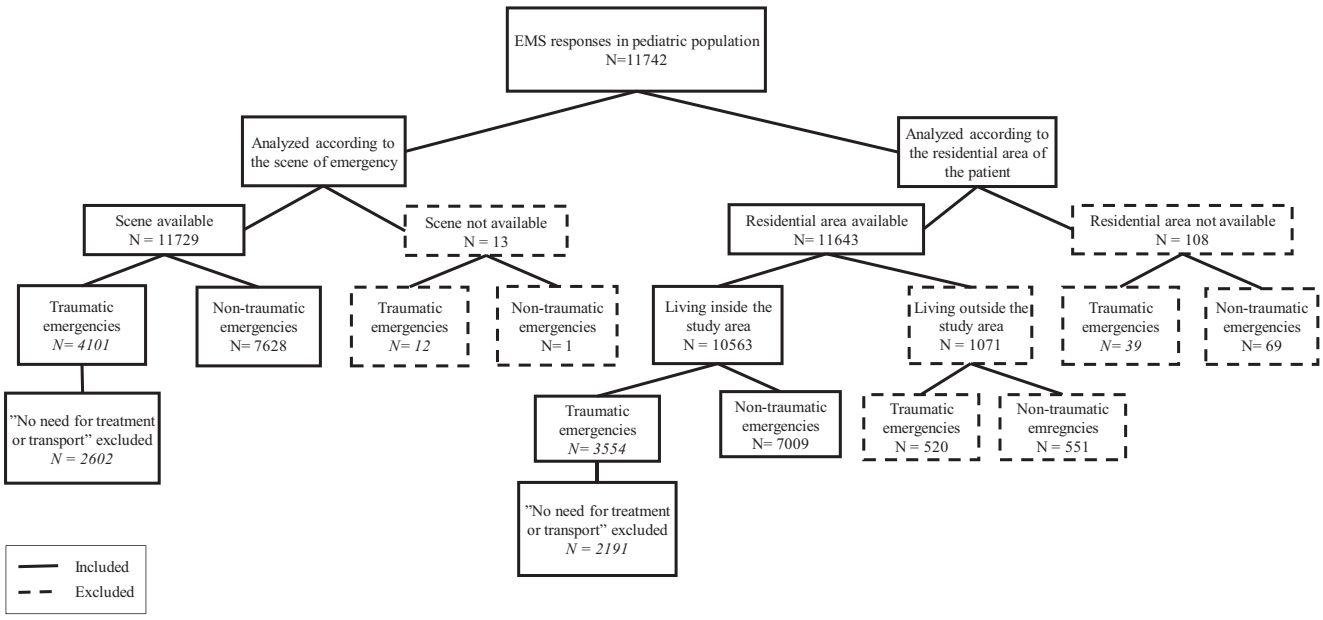

Fig. 2. Patient flow for analyses according to the scene of emergency and the residential area of the patient. EMS = emergency medical services.

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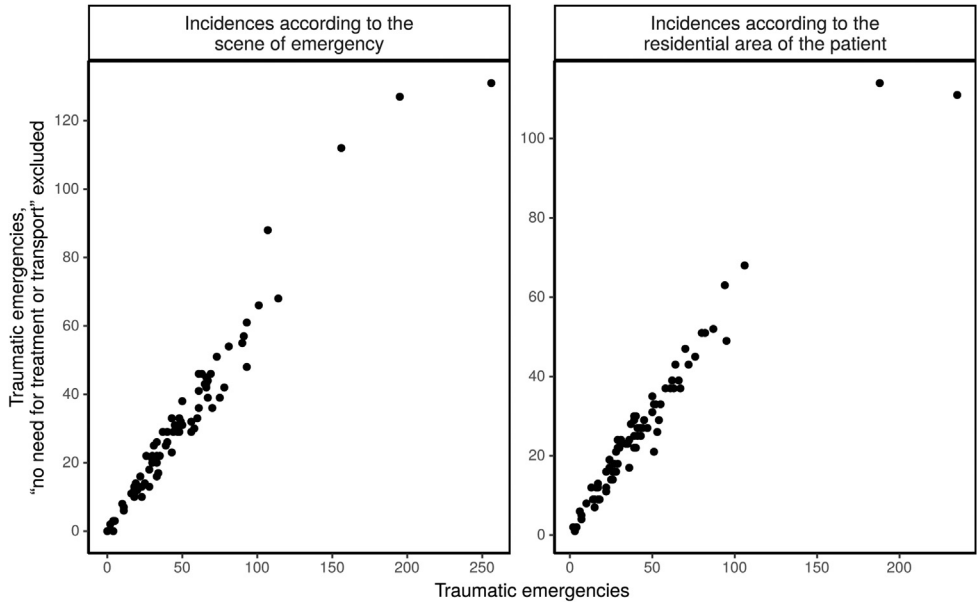

Fig. 3. Relation between the incidences of all traumatic emergencies and traumatic emergencies after exclusion of those leading to non-transport with the code "no need for treatment or transport".

Table 3
Results of regression analyses. Socioeconomic indicators of neighborhoods and incidences of 1) traumatic emergencies, 2) traumatic emergencies without those leading to nontransport with code "no need for treatment or transport", and 3) nontraumatic emergencies in a pediatric population.

	Type of emergencies	Traumatic (all)		Traumatic, "no need for treatment or transport" excluded		Nontraumatic	
		RR (CI)	P	RR (CI)	P	RR (CI)	P
Analyses according to the scene of emergency	**P**ediatric population[a] (%)	0.99 (0.98–0.99)	**0.005**	0.95 (0.93–0.97)	<**0.001**	0.97 (0.96–0.99)	**0.002**
	Mean age	0.99 (0.95–1.02)	0.503	0.99 (0.95–1.03)	0.555	1.01 0.98–1.04	0.684
	Households with children (%)	0.99 (0.98–1.00)	**0.010**	0.98 (0.97–0.99)	<**0.001**	0.98 (0.98–0.99)	**0.001**
	Academic degree (%)	0.999 (0.99–1.00)	0.739	1.00 (1.00–1.01)	0.586	0.99 (0.99–1.00)	**0.011**
	Unemployment level (%)	1.02 (0.99–1.04)	0.204	1.01 (0.98–1.04)	0.560	1.04 (1.02–1.06)	<**0.001**
	Native language other than Finnish or Swedish[b] (%)	1.01 (0.99–1.02)	0.441	1.00 (0.99–1.02)	0.887	1.02 (1.01–1.03)	<**0.001**
	Median income/>18 y inhabitant/year (per 1000€)	0.98 (0.95–1.00)	0.092	0.98 (0.95–1.01)	0.192	0.95 (0.93–0.98)	<**0.001**
	Mean income/>18 y inhabitant (per 1000€)	1.00 (0.99–1.01)	0.721	1.00 (0.99–1.01)	0.901	0.99 (0.98–1.00)	**0.037**
	Median income/household/year (per 1000€)	0.99 (0.98–1.00)	**0.043**	0.99 (0.98–1.00)	**0.019**	0.99 (0.98–0.99)	<**0.001**
	Mean income/household/year (per 1000€)	1.00 (0.99–1.00)	0.456	1.00 (0.99–1.00)	0.562	1.00 (0.99–1.00)	**0.016**
	Purchasing power/inhabitant/year (per 1000€)	1.00 (0.99–1.01)	0.916	1.01 (0.99–1.02)	0.401	0.99 (0.98–1.00)	0.120
Analyses according to the residential area of the patient	**P**ediatric population[a] (%)	1.01 (0.99–1.02)	0.422	1.00 (0.99–1.01)	0.809	1.00 (0.98–1.02)	0.916
	Mean age	1.00 (0.98–1.02)	0.857	1.02 (1.00–1.04)	0.086)	1.00 (0.97–1.03)	0.866
	Households with children (%)	1.00 (0.99–1.01)	0.758	1.00 (0.99–1.00)	0.558	1.00 (0.99–1.01)	0.664
	Academic degree (%)	0.99 (0.99–1.00)	<**0.001**	0.996 (0.99–1.00)	**0.016**	0.99 (0.98–0.99)	<**0.001**
	Unemployment level (%)	1.03 (1.02–1.04)	<**0.001**	1.02 (1.01–1.03)	**0.002**	1.06 (1.05–1.08)	<**0.001**
	Native language other than Finnish or Swedish[b] (%)	1.01 (1.01–1.02)	<**0.001**	1.01 (1.00–1.01)	**0.011**	1.03 (1.02–1.04)	<**0.001**
	Median income/>18 y inhabitant/year (per 1000€)	0.97 (0.96–0.99)	**0.001**	0.98 (0.97–1.00)	**0.013**	0.95 (0.93–0.96)	<**0.001**
	Mean income/>18 y inhabitant (per 1000€)	1.00 (0.99–1.00)	0.198	1.00 (0.99–1.01)	0.755	0.99 (0.98–1.00)	**0.001**
	Median income/household/year (per 1000€)	1.00 (0.99–1.00)	0.075	1.00 (0.99–1.00)	0.099	0.99 (0.98–1.00)	**0.001**
	Mean income/household/year (per 1000€)	1.00 (1.00–1.00)	0.339	1.00 (1.00–1.00)	0.766	0.99 0.99–1.00	**0.007**
	Purchasing power/inhabitant/year (per 1000€)	0.99 (0.99–1.00)	0.115	1.00 (0.99–1.01)	0.746	0.98 (0.97–0.99)	<**0.001**

RR = Risk ratio; CI = Confidence interval.
[a] 0–15-year-old.
[b] National languages of the study area.

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Table 4
Associations between the incidences of 1) traumatic emergencies, 2) nontraumatic emergencies and 3) traumatic emergencies without those leading to nontransport with code "no need for treatment or transport" in the pediatric (0–15 years) population and socioeconomic factors. Multivariate analyses included the following variables: 1) proportion (%) of households with children, 2) median income/year (/household for analyses according to the scene of emergency and />18 y inhabitant for analyses according to the residential area of the patient, estimate per 1000€), 3) proportion (%) of adult population with academic degree, and 4) proportion of population with native language other than Finnish or Swedish (national languages of the study area).

Type of emergency	Variable	RR	CI	P
Analyses according to the scene of emergency				
Traumatic (all)	**H**ouseholds with children % (mean)	0.98	0.96–1.00	0.092
	Median income/household/year (1000€, mean)	1.01	0.99–1.02	0.603
	Adults with academic degree % (mean)	1.00	0.99–1.01	0.500
	Native language other than Finnish or Swedish % (mean)	1.00	0.98–1.02	0.904
Nontraumatic	**H**ouseholds with children % (mean)	0.98	0.96–0.99	**0.011**
	Median income/household/year (1000€, mean)	1.01	0.99–1.02	0.319
	Adults with academic degree % (mean)	0.99	0.99–1.00	0.130
	Native language other than Finnish or Swedish % (mean)	1.01	1.00–1.03	0.125
Traumatic, "no need for treatment or transport" excluded	**H**ouseholds with children % (mean)	0.96	0.94–0.99	**0.003**
	Median income/household/year (1000€, mean)	1.01	0.99–1.03	0.276
	Adults with academic degree % (mean)	1.00	0.98–1.01	0.429
	Native language other than Finnish or Swedish % (mean)	1.00	0.98–1.02	0.974
Analyses according to the residential area of the patient				
Traumatic (all)	Households with children % (mean)	1.00	0.99–1.01	0.622
	Median income/>18 y inhabitant/year (per 1000€)	0.99	0.96–1.03	0.789
	Adults with academic degree % (mean)	1.00	0.99–1.02	0.772
	Native language other than Finnish or Swedish % (mean)	1.01	1.00–1.02	**0.032**
Nontraumatic	Households with children % (mean)	1.00	0.98–1.01	0.503
	Median income/>18 y inhabitant/year (per 1000€)	1.00	0.96–1.05	0.968
	Adults with academic degree % (mean)	0.99	0.98–1.00	**0.023**
	Native language other than Finnish or Swedish % (mean)	1.01	1.00–1.02	0.140
Traumatic, "no need for treatment or transport" excluded	Households with children % (mean)	1.00	0.99–1.01	0.651
	Median income/>18y inhabitant/year (per 1000€)	1.00	0.96–1.04	0.931
	Adults with academic degree % (mean)	1.00	0.99–1.01	0.610
	Native language other than Finnish or Swedish % (mean)	1.00	0.99–1.02	0.447

RR = Risk ratio; CI = Confidence interval.

level and a higher proportion of population with presumed immigrant background were associated with a higher incidence. When analyzed according to the residential area of the patient, a higher proportion of adult population with academic degree and all studied socioeconomic indicators indicating higher income level were associated with a lower incidence, while a higher unemployment level and a higher proportion of population with presumed immigrant background were associated with a higher incidence of nontraumatic emergencies among a pediatric population living inside a residential area.

As an example, based on the univariate models, a 10-percentage-point increase in the proportion of the pediatric population in the area would decrease the incidence of traumatic emergencies by 24.6%. Similarly, a 10,000€ increase in the median income per adult inhabitant per year would decrease the incidence by 20.8%.

All results of univariate regression analyses according to the scene of the emergency and the residential area of the patient are shown in Table 3.

In the multivariate models based on the scene of the emergency, there were no statistically significant associations between the incidence of traumatic emergencies and the socioeconomic factors examined. In nontraumatic emergencies as well as in traumatic emergencies, when the EMS responses leading to nontransport with the code "no need for treatment or transport" were excluded, the proportion of households with children was associated with a lower incidence of emergencies. In the analyses based on the residential area of the patient, the proportion of population with native language other than the national languages was associated with a higher incidence of traumatic emergencies. But when those responses leading to nontransport with the code "no need for treatment or transport" were excluded, it was no longer statistically significant. In non-traumatic emergencies, the proportion of adult population with an academic degree was associated with a lower incidence of emergencies. The results of multivariate models are shown in the Table 4.

3. Discussion

In a Scandinavian high-income country with universal healthcare, out-of-hospital emergencies in children had a significant association with neighborhood socioeconomic characteristics. This association was, however, weaker for traumatic emergencies than for medical emergencies. This suggests that relative to medical emergencies, childhood injuries can more readily be prevented by societal measures aimed at decreasing health inequities, and that preventive measures in society have been effective and well targeted in our study population. As the results did not change after exclusion of the patients that did not require treatment or transport by EMS, we also showed that inappropriate use of EMS for nonurgent conditions is not the reason for socioeconomic differences in pediatric EMS contacts, and the association between neighborhood socioeconomic characteristics and childhood traumas exists even for the potentially most severe traumas.

We used two different approaches for all comparisons. First, we analyzed the distribution of EMS contacts according to the scene of emergency and then we looked at the same distribution according to the residential areas of the contacted patients. These different approaches enabled us to estimate whether the detected socioeconomic differences would more likely be because of differences in the neighborhoods themselves (e.g. traffic hazards, unsafe playing grounds), or whether these risk factors would be traceable to the children's backgrounds (i.e. areas with families with poor resources for adequate supervision and safe parenting). If a particular area has more emergencies for all children, this *area* can be seen as a risk area; if particular children are at risk wherever they go, these *children* can be considered at risk.

Income was inversely associated with the risk of traumatic emergencies in children. A higher income level both in the area of the scene of the emergency and in the area where the child was living was associated with a lower incidence of traumatic emergencies in children. This indicates that children living in areas with lower income were at greater

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risk for injuries even when they traveled outside of these areas; inversely, all children were at greater risk for injuries when they spent time in low-income areas. However, the association of income with traumas was considerably weaker than that of income with medical emergencies. It is interesting that the inverse association of mean or household income with pediatric traumas was not seen for purchasing power in these areas. It is possible that in a Scandinavian-type welfare country, such as Finland, low purchasing power is not an accurate measure of socioeconomic disadvantage, as it does not necessarily take into account all publicly provided welfare. It is also possible that income is not only an independent factor, but also an indicator of other welfare, e.g. higher education, social inclusion, and employment.

Education and employment had similar associations with the risk of pediatric traumas, suggesting that these parameters may be interrelated. Education was protective only when analyzed according to the residential areas of the patients, indicating that children living in areas with less educated or unemployed adults had a greater risk for traumas regardless of where they stayed. Similarly, a previous study has shown that children with less educated mothers were at higher risk for injuries [7], suggesting that the protective effect of parental education follows the child. This could be because of more active attitudes and better resources for injury prevention as a result of better health literacy in educated families.

We also included native language as a measure of presumed immigrant background. In Finland, immigration is a relatively recent phenomenon, and thus, native language can be used as a proxy for recent immigration background. The risk-increasing effect of immigrant population was seen only when analyzed according to the residential areas of the patients: children from areas with higher proportion of presumed immigrants were at a greater risk for injuries anywhere, but other children were not at increased risk when they visited these areas. Language may play an additional role in this risk, as it might affect the ability to understand guidelines, directions, and warnings. However, as the results did not change with exclusion of inappropriate EMS contacts, the overrepresentation of children from areas with many immigrants does not seem to be because of the ERC having a lower threshold for EM responses because of communication problems during the emergency call.

Our results showed a protective effect of the proportion of children and families with children living in the area; the more children lived in a neighborhood, the less injuries all children had in these areas. This association did not follow the children from these areas to other areas but seemed to be related to the area itself. Presumably, families with children tend to concentrate in areas planned in a child-friendly way and where adequate protective measures have been undertaken. Thus, these areas may be safe for play for children from all social backgrounds. This finding underlines the importance of urban planning in injury prevention. It also raises a question about protection offered by social interaction between families with children — possibly, they share information and demand and construct services for families, contributing to making their neighborhood safer for all.

Many previous studies [19–21] reporting an increased use of emergency services in patients with lower socioeconomic status have explained the difference with an increased number of low-acuity contacts in patients with a lower socioeconomic status. Our results do not support this view. As the exclusion of EMS contacts leading to nontransport with the code “no need for treatment or transport” did not change our results, and as the relation between all traumatic emergencies and traumatic emergencies after exclusion of those with nontransport code “no need for treatment or transport” was linear, the associations we noted are not because of inappropriate use of EMS for nonurgent conditions. Instead, socioeconomic differences in the incidence of all EMS contacts and traumatic emergencies truly existed; this also confirms the results from our previous study [11]. This may also suggest that the proportions of low- and high-impact injuries did not vary between the areas with different socioeconomic status, as high-impact injuries always require treatment and transport independently of the clinical status of the patient according to the local EMS protocol.

Contrary to our expectations, the association between traumatic emergencies and socioeconomic factors was less prominent than the association between nontraumatic emergencies and socioeconomic factors. One could claim that there were not enough socioeconomic differences between the studied areas. In any case, the variables that we used markedly varied between areas, as seen in Table 1 and in Supplementary Table 1. A clear association between nontraumatic emergencies and neighborhood socioeconomic factors confirms that socioeconomic differences in pediatric emergencies existed in our study population, but these inequities were smaller for the incidence of pediatric trauma. This suggests that societal measures undertaken in Scandinavian countries to tackle socioeconomic inequities in health have been more effective in childhood injury prevention than in overcoming differences in medical issues. Indeed, pediatric trauma mortality and incidence have decreased significantly in Finland in the last decades owing to specific injury prevention campaigns [12]. According to our results, this decrease seems to have reached all social classes. Prevention of injuries may be easier to target equally in a society than prevention of social inequity.

We also conducted multivariate analyses to determine interrelations between the factors examined. In multivariate analyses, only a few of the factors remained statistically significant. This was not surprising since an association between socioeconomic disadvantage and traumatic emergencies in pediatric populations has been demonstrated earlier [5,18]. The results suggest that socioeconomic indicators form complex, multidirectionally interrelating networks without simple linear causalities. The results of multivariate analyses do not mean that the results of univariate analyses are irrelevant. Instead, they confirm that the socioeconomic factors examined represent different but strongly interrelated aspects of welfare. Still, the proportion of households with children was independently associated with a lower incidence of both nontraumatic emergencies and traumatic emergencies in residential areas when the inappropriate EMS contacts were excluded, suggesting that urban planning and structures may have preventive effects across social classes. A High proportion of inhabitants with native language other than national was an independent risk factor for traumatic emergencies in the pediatric population living inside a residential area. This supports our hypothesis, discussed above, that language itself may play role in the risk of traumatic emergencies.

Considering that school-aged children and teenagers are at greater risk for injuries [12], the age distribution of pediatric traumatic emergencies in our study population is surprising. It is possible that the age distribution reflects a lower threshold of caregivers, both at home and in daycare, to contact the ERC for young children.

Strengths of our study lie in a full coverage of all EMS contacts in the population and the possibility to compare these patients with population characteristics in exactly the same population. Because of the centralized ERC and publicly financed single-provider EMS, our data cover all EMS responses in the study population. Since the professional ERC operators screen the emergency calls before dispatching, the incidence of EMS responses in an area reflects the true incidence of emergencies. Finally, because of the systematic classification of nontransport decisions, we could assess the possible effect of inappropriate EMS use for nonurgent conditions. We also were able to evaluate the effects of socioeconomic factors on incidence of traumas inside an area as well as among children living inside a residential area, and these approaches may be used for different purposes. The associations detected in our study were also clinically relevant and significant, as with a 10-percentage-point increase in the proportion of the pediatric population in the area, the incidence of traumatic emergencies in children decreased by 24.6%, and with a 10,000€ increase in the yearly median income, the incidence decreased by 20.8%.

Our study also has several limitations. First, these results may not directly be generalizable to other areas, including rural areas, countries

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with very different EMS, healthcare systems, or profiles of pediatric trauma. Second, we could not include injuries either missed by the ERC or directly transported to EDs by means other than ambulance. However, as the EMS is easily accessible regardless of socioeconomic status, and the high nontransport rate suggests that the ERC dispatch protocol is highly sensitive at the expense of specificity, we expect the rate of missed patients to be low. Third, emergencies occurring to residents of Helsinki but temporarily residing outside the city could not be included; still, in more than 90% of the traumatic emergencies, the patient resided in Helsinki, indicating that temporary movement to other areas may not be that significant. Fourth, individual socioeconomic data were not used. Area-based approaches have been used and validated before [5,18,21–23]. Also, for public health promotion and administrative purposes, it is more important to identify risk populations than individuals at risk.

The socioeconomic and demographic variables examined did not change markedly inside the postal code areas included during the four-year study period (Supplementary Table 1). Thus, we deemed the use of mean values to be adequate for this purpose. Besides, strongly varying variables would not be utilizable for long-term planning or resource allocation.

Our study represents associations, not necessarily causalities, between the incidence of traumatic emergencies in children and neighborhood socioeconomic factors. If causality exists, these results cannot state whether poor socioeconomic status leads to worse health outcomes, or vice versa. The true risk factors may also be something other than those we measured. Many risk behaviors, e.g. substance abuse and mental health problems, have socioeconomic differences; these behaviors can affect parental resources, attitudes, and parenting styles, and lead to differences in children's exposure to safety hazards, and, ultimately, to differences in the incidence of traumatic emergencies. Many of the studied socioeconomic parameters may also be interrelated and not independent risk factors (e.g. income and employment). However, establishing causality was not necessary for the purposes of this study, as we aimed at finding injury risk factors for future planning of EMS and ED services and for targeting of preventive measures.

The results of this study can directly be used to target EMS and ED resources to areas where traumatic emergencies are more likely to occur, and also to allocate preventive measures to pediatric populations at the highest risk for traumatic emergencies. The possible protective effect of urban planning is encouraging and merits further studies.

4. Conclusions

We confirmed an association between the incidence of out-of-hospital emergencies in children and socioeconomic characteristics of the neighborhood, and, determined that it was not because of inappropriate use of EMS for nonurgent conditions. The association of socioeconomic parameters with the incidence of traumatic emergencies was weaker than the association of socioeconomic parameters with medical emergencies. Thus, the association between all out-of-hospital emergencies and socioeconomic parameters was not explained by traumatic emergencies. This may reflect the fact that preventive measures in society have been effective and well targeted in our study population residing in a Nordic welfare state. The protective role of pediatric populations and families with children in the area suggests that urban planning and other social and societal measures taken to provide safe housing and safe environments for children are beneficial. The use and allocation of these measures for prevention of pediatric trauma warrant further research.

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