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ORIGINAL ARTICLE

Differences in child injury hospitalizations in Sweden: The use of time-trend analysis to compare various community injury-prevention approaches

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Abstract

Aim: Sweden's child injury fatality rates are among the lowest in the world. The country has engaged in a number of community injury-prevention programmes. The purpose of this study was to compare child injury hospitalization rates from the Skaraborg District with the rest of Sweden. Our study hypothesis was that municipalities that offered comprehensive child injury-prevention programmes would see significant decreases in their child injury hospitalization rates, compared with other areas. *Methods*: The study areas comprised three groups, consisting of municipalities in Skaraborg that had adapted the Safe Communities approach to injury prevention programmes, other municipalities in the District, and the rest of Sweden. The aim of the analysis was twofold: (1) to fit time trends for children's injuries in various areas in an integrated manner; and (2) to compare time trends across locations between community safety-promotion programmes as well as with the control areas. Panel data models and parametric splines were used. *Results*: There were differences between incidence rates in the study areas and with regard to gender. There was a steep decrease in injury rates in one of the Safe Communities study areas for both genders. *Conclusions*: The methods applied in this analysis reveal more detailed and sophisticated time trends than the usual simple linear regression approach. The model provided a clearer view of the interactions of gender, area, and time as they impacted on children's injuries, and allowed for better insight into the impact of safety programmes.

Key Words: *Child injuries, Skaraborg, Sweden, time trend analysis*

Introduction

Sweden's child injury fatality rates are among the lowest in the world, at 5.2/100,000 children, with a comparable USA rate of 14.1/100,000 [1]. Sweden's success in addressing child injuries has occurred over a relatively short period of time. During 1957–59, Bergman and Rivara (1991) reported almost equal injury fatality rates for groups of children in Sweden and the USA; 30 years later, however, the USA's rates were almost unchanged, whereas Sweden's rates fell from about 47/100,000 to 6/100,000 among 1- to 4-year-olds and from 18/100,000 to 7/100,000 among 5- to 14-year-olds [2]. When discussing effective approaches to child-injury reductions, Ellsässer and Berfenstam (2000) point to the importance of analysing surveillance data and comparing intervention programmes [3]. A number of studies analysing changes in injury rates in what was formerly known as Skaraborg County, now Skaraborg District, Sweden, describe these methods [4–6].

Although the types of injury prevention programmes targeting children differ within its localities, Skaraborg District has consistently applied three common programmes throughout its municipalities: (1) education on safety issues to County

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Council healthcare personnel, who in turn can provide this expertise to parents; and information provided directly to parent; (2) [arent loan programmes for children's car seats, through hospitals and other distribution sites, covering all newborns; and, (3) bicycle helmet discount programmes for all one- and three-year-olds in the District [7,8]. One of the longest running child injury-prevention programmes within the District is located in Lidköping, where local health authorities and municipal members formed a child injury-prevention taskforce under its Safe Communities programme, beginning in 1984. This Safe Communities model has been the subject of more than a dozen studies and reports [3–19]. Lidköping's development of child-injury initiatives is typical of similar efforts throughout the county, and can be used as an illustration of the template that is adopted in other areas in Skaraborg, including Falköping, Skövde, Mariestad, and Tidaholm. In Lidköping, a Child Injury Prevention Taskforce met regularly, four times a year, under the sponsorship of the local Safe Communities programme. Members were representatives from child-healthcare, the children's clinic and surgery departments at the local hospital, child social services, schools, emergency services, environmental health, street office (a road engineer), consumer safety programme, police department, dental care ward, maternal health, the Red Cross, and the local community public-health officer. The general strategy of the programme was based on surveillance of injuries, information distribution to healthcare providers, teachers and parents, training of personnel who work with children, and ongoing supervision and modification of environments frequented by children [6].

Programme initiatives in other safety areas also had an impact on child safety. In Lidköping, during the study period, particular emphasis was placed on environmental modifications as part of a project called ''Vision Zero''. The goal of this national project was to reduce fatalities and serious injuries from transportation causes to zero. The Vision Zero project in Lidköping lasted until the end of this study period. Programme components included:

- construction and maintenance of footpaths and bicycle paths and protected crossings at roadways;
- environmental modification of streets in order to reduce speed;
- free delivery of sand for fall prevention of pedestrians; and
- participation of local community groups participating in the traffic planning.

Given its history of municipal responses to injury problems, it is reasonable to suppose that Lidköping formed something of a model municipality – but how did its performance compare against other Swedish municipalities, including those that also featured similar approaches? Skaraborg's municipalities offered a natural laboratory in which to assess the effectiveness of various child-injury programmes. Our study hypothesis is that municipalities that offered comprehensive child injury-prevention programmes would see significant decreases in their child injury hospitalization rates, compared with other areas.

Material and methods

Study area, population, and study period

The geographic area for this study, Skaraborg District, has a population of about 250,000 inhabitants and is situated between Gothenburg and Stockholm in western Sweden, between two large lakes (Vänern and Vättern) (Figure 1). The district comprises 15 municipalities, ranging between 50,000 and 6,000 inhabitants. The entire district covers an area of 8,210 km^2, of which 40% is arable land (compared with 8% throughout the rest of Sweden). During the study period for this paper, the

Figure 1. Study areas of Falköping, Lidköping, Mariestad, Skövde, and Tidaholm, and the ''Rest of Skaraborg district'', which lie between Sweden's biggest lakes, Vänern and Vättern. Map is adapted and used with permission of http://www.skaraborg.se

district had three hospitals providing medical care on a 24-hour basis, of which two – the district hospital in Skövde and the hospital in Lidköping – had paediatric departments with inpatient care. Skövde Hospital still provides these services, while Lidköping Hospital provided such services until 31 December 1996. Lidköping's emergency-acute department took in all paediatric cases requiring such care, but more seriously injured children were then transported to the district hospital in Skövde.

The study period ranged from 1987 to 2001. The reasons for starting in 1987 were to meet requirements for high quality and validity of injury data from the various municipalities. Five municipalities were selected within Skaraborg district for special analysis: Lidköping, where a community safety prevention programme started in 1984 (some child-injury interventions occurring as early as 1982), Skövde, where a community safety programme began in 1988, Tidaholm (where a similar programme began in 1988), Mariestad (whose programme began in 1989), and Falköping (whose programme began in 1979, and was reorganized in 1991). All areas are designated Safe Communities by the WHO Collaborating Centre on Community Safety Promotion [20]. The study population (Table I) consisted of children living in the above five municipalities who were 14 years old and under, for each year of the study period. In addition, the same data material was gathered for the 10 remaining municipalities in the District, hereby called the "Rest of Skaraborg District", and for the "Rest of Sweden".

Outcome data

Records of unintentional injuries requiring hospitalizations ⩾24 hours for children 0–14 years of age were obtained from Sweden's national hospital-discharge register. Records were included for analysis if they were coded as E807 to E929, according to ICD-9 [21] 1987 to 1996, or V01-X5999, according to ICD-10 for 1997 onwards [22]. Patients were identified by their place of residence, not by the hospital where they were treated. Each patient was counted only once per year so that any individual would make only one injury contribution annually. All hospital discharge data were classified by age and gender groups.

Table I. Population sizes at the end of the study period (2001) for children aged 0–14 years in Lidköping, Falköping, Tidaholm, Skövde, and Mariestad and "Rest of Skaraborg District", and "Rest of Sweden".

Study populations	Girls	Boys	Total
Lidköping	3,402	3,557	6 959
Falköping	2,689	3,007	5 696
Tidaholm	1,164	1,245	2 409
Skövde	4,402	4,425	8 827
Mariestad	2,095	2,215	4 310
Rest of Skaraborg	10 991	11 461	22 452
Rest of Sweden	764,279	805,343	1,569 622

Unintentional injuries for children 0 to 14 years were counted and grouped into 14 time series, henceforth called panels, of yearly incidence rates. Boys and girls were regarded separately for each of the seven intervention or control areas, due to the tendency of boys to demonstrate higher injury rates. The aim of the statistical analysis is twofold: (1) to fit time trends for panels in an integrated manner, i.e. based on a single model; and (2) to compare time trends across municipalities with community safety-promotion programmes as well as with the control areas. To allow for geographic and gender differences, the first model consisted of main effects and interactions of three factors, regardless of statistical significance: gender, area, and time [23]. Dummy variables represented gender and areas, whereas the temporal dimension was depicted as time trends represented with parametric splines. A further regression analysis was carried out selecting only statistically significant main effects and interactions of the full model. For fitting random effect models we used MLwiN 2.0 [24] whereas for fixed effect models we used the procedure xtgls from STATA 8.0 [25].

The panel of boys in the Rest of Sweden was the reference. Remaining panels were regarded with dummy variables. Time was a discrete variable centred on the year 1994 (time reference). Therefore, the model intercept represents the mean incidence rate for boys in the Rest of Sweden in 1994. For the specification of the other panels the corresponding intercept and linear time coefficient must be added to the respective coefficients in the reference community. The error component was allowed to vary across panels. (An alternative to the above model specification is to carry out further modelling, e.g. excluding from the current model the most non-significant term, one term at a time, starting with the full model up to all remaining terms being statistically significant [$\alpha=0.05$].) Autocorrelation within panels was tested, both under a general autoregressive AR (1) process and a panel-specific AR (1) process. Chi-squared tests were used for comparing nested models. Graphical displays of observed and predicted values were examined throughout the analyses as well as normal plots, plots of residuals versus fitted values, and of

residuals versus year for violations of the model assumptions.

Results

Modelling steps are shown in Table II. Table III gives the results from full and reduced models. Autoregressive terms were not statistically significant, so are not shown. Compared with the Rest of Sweden, child-injury hospitalization incidences differed most in Skövde (difference in deviance =31.77, in 4 degrees of freedom) and Lidköping (difference in deviance =24.71, in 4 df) , whereas Mariestad (difference in deviance =2.48, in 4 df) and Falköping (difference in deviance =6.01, in 4 df) did not differ significantly from the Rest of Sweden. Finally, Tidaholm (difference in deviance =8.39, in 4 df) and the Rest of Skaraborg (difference in deviance =11.18, in 4 df) were somewhat different ($p<0.10$ and $p<0.05$, respectively) from the Rest of Sweden.

The overall gender difference in the Rest of Sweden in 1994 was highly statistically significant (beta=−3.3893, s.e.=0.0887). So also were the gaps between the mean incidence rates at Falköping (beta=2.8022, s.e.=0.6990) and Skövde (beta=3.2581, s.e.=0.4727) but less so in Tidaholm (beta=2.1077, s.e.=1.1236), each compared with the Rest of Sweden in 1994. The predicted means in these areas in 1994 were above the national mean (Rest of Sweden). Lidköping differed significantly from the Rest of Sweden in that the linear term and the associated coefficient were the most negative of all areas (beta=−0.6546, s.e.=0.1486), revealing that Lidköping experienced a steeper decrease in mean incidence rates than the other areas. Unlike Lidköping, Skövde experienced an increase in incidence rates over the years (beta=0.2647, s.e.=0.1094). The gender gap between predicted means in 1994 was also larger in Skövde than in the other areas (beta=−2.6498, s.e.=0.6176). Finally, the linear term corresponding to the Rest of Skaraborg was negative (beta=−0.1577, s.e.=0.0919), showing that in this region there was also a slight decrease in predicted incidence rates.

In all areas girls presented a lower level of incidence rates than boys, but in Skövde the gender gap between the two groups was larger. Falköping, Lidköping, Skövde, Tidaholm, and Skaraborg showed higher predicted incidence rates than the Rest of Sweden in 1994, but the difference in Lidköping was weak ($0.15<p<0.20$). Judging by the linear coefficient, there was a slight but significant increase in the incidence rates in the Rest of Sweden in the study period. Mariestad, Tidaholm, and Falköping shared this pattern with the Rest of Sweden, whereas in Skövde the increase was steeper.

In Figure 2 the observed and fitted values over time for panels of girls and boys are displayed in the same scale. The fitted values were calculated according to the full model. For some panels such as that for boys in Tidaholm, the time trend might look as if it does not fit the data; however, inclusion of further terms proved not to be statistically significant. In Falköping, the incidence rates for boys and girls demonstrated similar temporal patterns and fluctuate around constant values. In Lidköping, the incidence rates of both genders tended to fall sharply over the years, this being a unique feature of the present analysis. In Mariestad, rates for boys and girls also seem to fluctuate around two constant values. Interestingly, the incidence rates for girls and boys in Skövde showed a slow but steady increase over the study period. In Tidaholm, incidence rates for girls and boys had diverging time patterns, with the panel for girls showing a tendency

Table II. Summary of modelling.

Model	Random intercept variance (s.e.)	Model deviance	Difference in model deviances	df	*p*-value
Random intercept + homoskedastic error	4.617 (1.893)	1002.20	—	–	—
Random intercept + heteroskedastic error	4.620 (1.882)	873.17	129.03	13	<0.001**
+ Fixed-effects spline	4.613 (1.878)	853.48	19.69	4	<0.001**
+ Random-effects spline	4.613 (1.878)	853.48	0.00	6	1.00
+ Gender (in Rest of Sweden)	0.735 (0.381)	831.48	22.00	2	<0.001**
+ Falköping	0.296 (0.194)	825.47	6.01	4	0.1984
+ Lidköping	0.251 (0.167)	800.76	24.71	4	<0.001**
+ Mariestad	0.283 (0.180)	798.28	2.48	4	0.6482
+ Skovde	0.000 (0.000)	766.51	31.77	4	<0.001**
+ Tidaholm	0.000 (0.000)	758.12	8.39	4	0.0783*
+ Rest of Skaraborg	0.000 (0.000)	746.94	11.18	4	0.0246*

Table III. Summary of final model (systematic effects, standard errors, and *p*-values).

Covariates	Full model	Reduced model
Constant	11.1412 (0.1011)*	11.1796 (0.0834)*
Girls	−3.3893 (0.0887)*	−3.4012 (0.0832)*
Falköping	2.8022 (0.6990)*	2.1202 (0.3668)*
Lidköping	0.3935 (0.6420)	
Mariesberg	0.04862 (0.6666)	
Skövde	3.2581 (0.4727)*	3.2457 (0.4489)*
Tidaholm	2.1077 (1.1236) ⊥	1.4515 (0.6222) †
Skaraborg	0.6343 (0.3969)	0.7065 (0.2523)*
Girls * Falköping	−0.9413 (0.8270)	
Girls * Lidköping	0.2638 (0.8510)	
Girls * Mariesberg	−0.1630 (0.8419)	
Girls * Skövde	−2.6498 (0.6176)*	−2.6379 (0.5863)*
Girls * Tidaholm	−0.9511 (1.3436)	
Girls * Skaraborg	0.1405 (0.5303)	
Year (centred) linear	0.0802 (0.0273)*	0.0838 (0.0215)*
Year (centred) squared	0.0293 (0.0146) †	0.0225 (0.0047)*
Year (centred) cubic left	0.0010 (0.0022)	
Year (centred) cubic right	−0.0065 (0.0022)*	−0.0056 (0.0012)*
Girls * Year linear	0.0018 (0.0205)	
Falköping * Year linear	−0.0310 (0.1618)	
Lidköping * Year linear	−0.6546 (0.1486)*	−0.5620 (0.0973)*
Mariesberg * Year linear	0.1346 (0.1543)	
Skövde * Year linear	0.2647 (0.1094) †	0.2489 (0.0668)*
Tidaholm * Year linear	0.2082 (0.2601)	
Skaraborg * Year linear	−0.1577 (0.0919) ⊥	−0.1178 (0.0583) †
Girls * Falköping * Year linear	−0.0274 (0.1914)	
Girls * Lidköping * Year linear	0.1680 (0.1970)	
Girls * Mariesberg * Year linear	−0.1099 (0.1949)	
Girls * Skövde * Year linear	−0.0271 (0.1429)	
Girls * Tidaholm * Year linear	−0.4311 (0.5303)	
Girls * Skaraborg * Year linear	0.0719 (0.1227)	

* $p<0.01$; † $0.01<p<0.05$; ⊥ $0.05<p<0.10$.

to decrease. Finally, in the Rest of Skaraborg District there was a slight decrease for both girls and boys.

Discussion

Hospital discharge registries are commonly used in morbidity studies. Sweden's hospital registries offer a wealth of information about country- and county-level health and injury patterns. Sweden has few private hospitals and, according to a report of the Swedish Federation of County Councils in 2004, no beds for children are available in private hospitals. The proportion of missing cases from the national registries (non-registered injuries) was calculated to be less than 1% of the cases [26].

Due to possible changes in admission policies, therapeutic technologies, and diagnostic coding practices over time, interpretation of time trends revealed by inpatient data analysis must be drawn carefully. Two practical changes could have influenced the counts of children's injuries in the study period, hence the interpretation of this study's findings. Both events occurred in 1996: the closure of the inpatient care child ward at Lidköping hospital and the change by hospital registries from ICD-9 to ICD-10 categorization schemes. If these changes had an effect in increasing or decreasing the mean incidence levels the model would have integrated them in the time trends and would have allowed identification of this effect by means of comparing the two cubic terms of the spline. Indeed, while the first cubic term is not significant, the second cubic term, corresponding to the period 1995–2001, is statistically significant, revealing a more complex trend during the second half of the study period. As for the closing of the hospital ward in Lidköping, the results of this action may have had an effect on this municipality's injury surveillance data, as analysis of injuries to children in Lidköping and neighbouring municipalities (most cases using Lidköping Hospital before its closure) showed a decrease in hospitalizations after this hospital closure. However, personal interviews with key informants, including the hospital administrator, chief surgeon, and chief paediatrician in Lidköping, indicated no changes in routines of treatment or referrals for hospitalizations

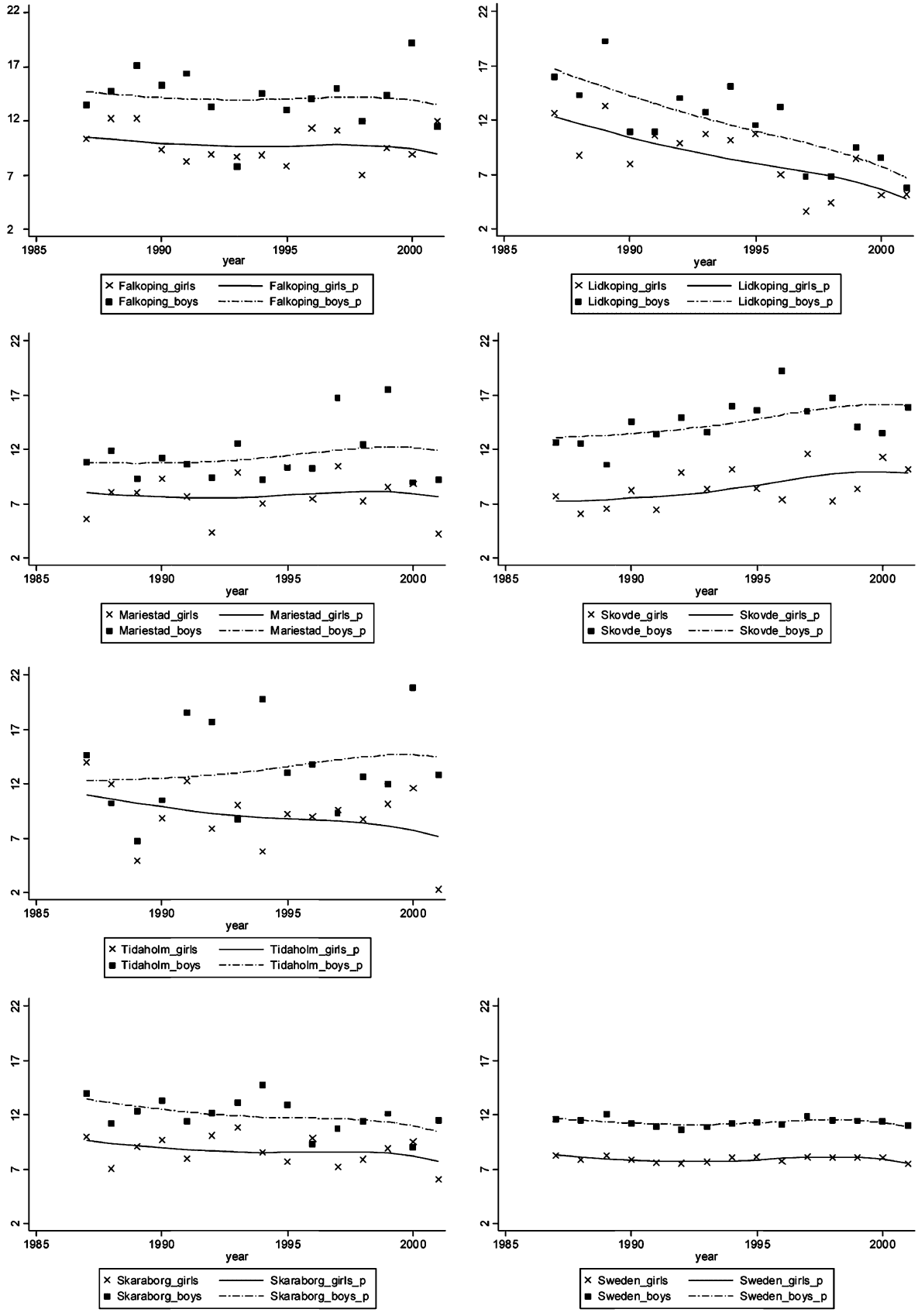

Figure 2. Observed incidence rates and model predictions for boys and girls (0–14) in five municipalities, Rest of Skaraborg District and Rest of Sweden.

Table IV. Summary of estimated within-panel variances.

Panel	Full Model	Reduced Model
Falköping girls	2.4666	2.5978
Lidköping girls	3.9601	4.4760
Mariestad girls	3.3494	3.3917
Skövde girls	1.9886	1.9741
Tidaholm girls	6.9080	7.9176
Rest of Skaraborg girls	1.5504	1.5715
Rest of Sweden girls	0.0308	0.0307
Falköping boys	6.1771	6.6932
Lidköping boys	5.1996	5.4873
Mariestad boys	5.6124	5.9718
Skövde boys	2.7869	2.7663
Tidaholm boys	16.0717	17.2474
Rest of Skaraborg boys	1.9443	1.9609
Rest of Sweden boys	0.0697	0.0732

in other facilities for injured children who first presented at that hospital. In addition, all children who were included in this study were identified by their area of residence, no matter where their care was provided, thus it is assumed that the vast majority of children from the affected areas were captured by this study.

The previously reported decrease in injury rates in Lidköping over the period 1983 to 1991 seems to have continued right up to the end of the current study period (1987–2001) [6]. However, the modelling results show no significant change over time for Falköping. Tidaholm's programme, which had already been implemented at the beginning of this study's time frame, may well have had an effect on that area's decrease in injuries. A lack of detailed programme evaluations for this area makes further interpretation of this outcome difficult.

It is possible that the effects of long-running community safety programmes in Falköping and Lidköping may have influenced the incidence of unintentional injuries among children. However, other study areas, including Mariestad and Tidaholm, with newer programmes, still show unclear trends (except decreases for girls in Tidaholm). Skövde, where the district hospital is situated, shows an increasing trend.

It is difficult to sort out the effects of a specific intervention as it relates to decreased injury patterns within a specific municipality. The five study municipalities all initiated Safe Communities programmes that offered multiple interventions simultaneously with other community-safety promotions. Why, if the basic pattern for child-injury interventions was the same for all groups, is there so much difference in the outcomes, as judged by child injury hospitalizations? Part of the explanation may lie in the fact that, during the study period, Skaraborg District as a governmental unit ceased to exist: the region was incorporated into a new Swedish regional government, Västra Götaland, with many changes in personnel and programme priorities.

Within the former Skaraborg County area, the two municipalities with the longest running programmes, Falköping and Lidköping, also had strong local community and political support for their work, and did not experience much staff turnover, either in the health sector or within the municipal government sector.

Other Skaraborg programmes that followed the Lidköping and Falköping models were developed several years after these two programmes began. The relatively poorer performance of the newcomers may have been the result of political changes within these areas, and/or higher staff turnover within the three programmes. Frequency and intensity of injury-prevention efforts must be sustained – when differences are found in neighbouring municipalities that adopt essentially the same programme model, it is possible that there were differences in programme delivery that may explain, at least partially, varying outcomes. The better outcomes for Lidköping may also be partially explained by the ongoing presence of researchers examining the injury-prevention programme there. This ongoing interaction between local programme leaders and researchers may have contributed to a greater awareness of programme evaluation, for example, and/or a greater use of surveillance data to identify problem areas more quickly.

The study's results and observed differences point towards the need for deeper analyses of the social structures of the studied municipalities and differences in target populations, population sizes, underlying economic structures of municipalities (e.g. industry, agriculture), as well as local commitments to the community safety-promotion programme itself. These are to be aimed at in future studies.

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