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**Socioeconomic inequalities in injury mortality in small areas of 15 European cities**

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ABSTRACT

This study analysed socioeconomic inequalities in mortality due to injuries in small areas of 15 European cities, by sex, at the beginning of this century.

A cross-sectional ecological study with units of analysis being small areas within 15 European cities was conducted. Relative risks of injury mortality associated with the socioeconomic deprivation index were estimated using hierarchical Bayesian model.

The number of small areas varies from 17 in Bratislava to 2666 in Turin. The median population per small area varies by city (e.g. Turin had 274 inhabitants per area while Budapest had 76,970).

Socioeconomic inequalities in all injury mortality are observed in the majority of cities and are more pronounced in men. In the cities of northern and western Europe, socioeconomic inequalities in injury mortality are found for most types of injuries. These inequalities are not significant in the majority of cities in southern Europe among women and in the majority of central eastern European cities for both sexes.

The results confirm the existence of socioeconomic inequalities in injury related mortality, and reveal variations in their magnitude between different European cities.

**Keywords:** injuries, mortality, Europe, socioeconomic inequalities, urban areas, small areas

## INTRODUCTION

Injuries due to external causes, whether intentional or unintentional, are one of the leading causes of death worldwide. In Europe injuries account for 7% of all deaths every year, with traffic injuries (16%), poisonings (13%) and falls (10%) being the main causes of death related with unintentional injuries, and suicides (19%) and homicides (7%) the leading causes of intentional injuries (WHO, 2012).

In recent decades injury mortality rates have fallen in most European countries (EUROSTAT, 2012), however there are still differences between countries in mortality due to these causes. In concrete, people living in low and middle income countries are more likely to die from injuries than those living in high income countries. These differences have been observed for all specific causes of injuries, except for falls in women (Sethi, et al, 2006). In addition, individuals of less favourable socioeconomic positions present higher risks of dying due to the leading specific causes of death by injuries (Cubbin and Smith, 2002, Laflamme, et al, 2009).

In recent years there has been an increase in the number of studies of mortality inequalities in geographical areas, since area of residence has been recognised as a factor affecting health independently of individual determinants (Diez Roux, 2001). In the case of injury related mortality, some studies have found that areas with worse socioeconomic indicators present higher risks of dying, in particular for homicides (Leyland and Dundas, 2010, Krueger, et al, 2004) and drug overdose (Gotsens, et al, 2011a, Michelozzi, et al, 1999). In the case of suicides and traffic injuries the findings are inconclusive. Some studies have found associations, both positive (Gotsens, et al, 2011a, Burrows, et al, 2010, Esnaola, et al, 2006, Chang, et al, 2011, Middleton, et al, 2006) and negative (Middleton, et al, 2004, Page, et al, 2002) in the case of suicides, while others have found no association (Esnaola, et al, 2006, Middleton, et al, 2004). In the case of falls, few studies have analysed socioeconomic inequalities for this cause at area level, these studies have not found any association with socioeconomic deprivation of residence area (Gotsens, et al, 2011a). Finally, it is important to note that the socioeconomic inequalities in mortality due to injuries are more pronounced among men for the majority of causes (Gotsens, et al, 2011a).

In Europe, socioeconomic inequalities in injury related mortality at small area level have hardly been analysed, and the majority of studies have focused on comparisons between countries. Focus to urban population was rarely given, while, on one side, the majority of Europe's population lives in cities (United Nations), on the other it is in the urban areas where certain external causes, such as traffic injuries involving pedestrians, homicides, or substance abuse are more common (Vlahov and Galea, 2002). Thus, the objective of the present study was to analyse socioeconomic inequalities in mortality due to the leading injury related causes of death in small areas of 15 European cities by sex, at the beginning of the 21st century.

## METHODS

### *Design, unit of analysis and study population*

This was a cross-sectional ecological study which forms part of the INEQ-CITIES project (<https://www.ucl.ac.uk/ineqcities/>). The units of analysis were the small areas of 15 European cities. The selected cities of the study are the ones participating in this project. These cities were located in a variety of regions of Europe: North: Helsinki (Finland) and Stockholm (Sweden); West: London (UK), Amsterdam and Rotterdam (the Netherlands), Zurich (Switzerland) and Brussels (Belgium); South: Turin (Italy), Madrid and Barcelona (Spain), and Lisbon (Portugal); Central east: Budapest (Hungary), Kosice and Bratislava (Slovakia), and Prague (Czechia). The study population consisted of the individuals residents in the 15 cities during a period around 2000-2008.

### *Information sources*

The majority of cities had mortality data for the years 2000-2008 and socioeconomic indicators for 2001. Mortality data were obtained from the mortality registers of the cities or countries. Due to technical problems, georeferencing of place of residence could not be done for several deaths in 8 cities (percentage varying between 0.24% in Brussels to 2.75%). The population data stratified by age (in five-year groups), sex and small area were obtained from census data or from the Register of Inhabitants for each city. Socioeconomic indicators were also obtained from census data in the majority of cities except in,

Amsterdam and Rotterdam which were obtained from the Annual Labour Force Survey for the years 1996-2008 and Helsinki and Stockholm which were obtained from the Register for 2001.

*Mortality and socioeconomic deprivation index*

The present study has analysed all deaths due to injuries (International Classification of Diseases 9th edition -ICD9-: E800-E999, 304, 305 (and the 4th digits of ICD9: .2,.3,.4,.5,.6,.7,.8), International Classification of Diseases 10th edition -ICD10-: V01-Y89, F11-F16,F19) and from five specific causes of death due to injuries: transport injuries (ICD9: E800-E848, ICD10: V01-V99), drug overdoses (ICD9: E850(.0,.9), E851-E855, E858(.8,.9), 304, 305(.2,.3,.4,.5,.6,.7,.8), ICD10: X41-X44, F11-F16, F19), falls (ICD9: E880-E888, ICD10: W00-W19), suicides (ICD9: E950-E959, ICD10: X60-X84) and homicides (ICD9: E960-E969, ICD10: X85-Y09).

We included as a covariate an index of socioeconomic deprivation available for each small area of each city. The socioeconomic indicators included in the index were: (a) Unemployment: percentage of people aged 16 years or over unemployed or actively seeking job in relation to the total economically active population; (b) Manual workers: percentage of people aged 16 or over, employed, who are manual workers, in relation to the total employed population aged 16 or over; (c) Low education in young people (16-25 years): percentage of 16-25 years old population with primary education or lower level in relation to the total population aged 16-25 years; (d) University qualifications in young people (25-34 years): percentage of 25-34 years old population with university education in relation to the total population aged 25-64 years; (e) Foreigners low income countries: percentage of foreigners from low income countries in relation to the total population. Although the INEQ-CITIES project collected information on other socioeconomic indicators, the socioeconomic indicators that were used to create this index were the most comparable indicators across the cities. The index of socioeconomic deprivation was constructed by the DP2 method. DP2 is an iterative procedure that weights partial indicators depending on their correlation with the global index. This construction overcomes several limitations of the standard Principal Component Analysis method, for instance, aggregating variables expressed in different units of measurement, arbitrary weights, the treatment of missing values and duplicate information. In addition, the DP2 method allows a joint analysis of the data from all the cities in order to obtain a single index of

deprivation. Consequently, this deprivation index is comparable across all the cities studied (Pena Trapero, 1977, Salcedo, et al, 2012).

#### *Data analysis*

The mortality indicator used for the analysis is the Standardized Mortality Ratio (SMR). The SMR is dependent on population size since its variance is inversely proportional to the expected values, thus areas with low population tend to present estimates with a high variance. In order to smooth the SMR we used the hierarchical Bayesian model proposed by Besag, York and Mollié (BYM) (Besag, et al, 1991). This model takes two types of random effects into account, spatial and heterogeneous: the former takes account of the spatial structure of the data while the latter deals with non-structural (non-spatial) variability. Smoothed SMR (sSMR) were estimated for each cause of death, sex and city with the following model:

$$O_i \sim \text{Poisson}(E_i \theta_i)$$

$$\log(\theta_i) = \alpha + S_i + H_i \quad (\text{model 1})$$

where, for each area  $i$ ,  $O_i$  is the number of observed cases,  $E_i$  the expected cases,  $\theta_i$  the relative risk with respect to the European population,  $S_i$  the spatial effect, and  $H_i$  the heterogeneous effect. The expected cases in each small area were calculated by indirect standardization taking as reference the mortality rates of 25 countries of the European Union for the year 2004, by sex, age (in 5 year groups) and cause of death, these data having been provided by the World Health Organization (WHO 2011).

The geographical distribution of the SMR calculated through model 1 has been represented using maps of septiles. Moreover, the deprivation index has also been represented as septile maps. All maps were generated using the R statistical package (R Development Core Team, 2012).

In order to analyse the relationship between mortality and socioeconomic deprivation, we fitted an ecological regression model (model 2) which included the deprivation index ( $X_i$ ) as a covariate:

$$O_i \sim \text{Poisson}(E_i \theta_i)$$

$$\log(\theta_i) = \alpha + \beta_1 X_i + S_i + H_i \quad (\text{model 2})$$

where  $\exp(\beta_1)$  denotes the relative risk (RR) associated with the deprivation index.

In the two models (model 1 and model 2), an intrinsic conditional autoregressive prior distribution (ICAR)(Besag, et al, 1991) was assigned to the spatial effect, which assumes that the expected value of each area coincides with the mean of the spatial effect of the adjacent areas and has variance of  $\sigma_s^2$ , while the heterogeneous effect was represented using independent normal distributions with mean 0 and variance  $\sigma_h^2$ . A half-normal distribution with mean 0 and precision 0.0001 was assigned to the standard deviations  $\sigma_s$  and  $\sigma_h$  (Gelman, 2006). A normal vague prior distribution was assigned to the parameters  $\alpha$  and  $\beta_1$ .

Relative risk (RR) estimates were obtained based on their posterior means, along with the corresponding 95% credible intervals (95%CI). These distributions were obtained with the “Integrated nested Laplace approximation” (INLA) method, using the INLA library of the R statistical package, R.2.10.1 (Rue and Martino, 2009). This method provides reliable estimates of the posterior distributions avoiding the problems and computing time that would entail resorting to Monte Carlo methods.

The analyses were performed for each city stratifying by sex in order to control for possible interactions between socioeconomic deprivation and sex, due to the different impact of injury mortality in men and women (Laflamme, et al, 2009, Gotsens, et al, 2011a). Finally, for deaths due to homicides and drug overdose, modelling was not feasible for Stockholm, Turin, Madrid, Barcelona, Kosice and Prague due to the small numbers of deaths in respect to the number of areas in each city.

## RESULTS

Table 1 presents the number of small areas, the total population and the distribution of the population by small area in each city. The number of small areas varies from 17 in Bratislava to 2666 in Turin. The

median population per small area also varies by city. For example, the median population per area in Turin was 274 inhabitants while in Budapest it was 76,970 inhabitants. Both facts indicate that the size of the small areas with available data is different in each city. This table also includes a description of the deprivation index. The median value of deprivation index varies from 3.2 in Stockholm to 7.8 in Madrid and London. Higher scores in the deprivation index represented higher socioeconomic deprivation.

Table 2 presents the number of deaths by cause and sex in each city. In the majority of the cities, the number of deaths from all specific injury causes is higher in men, with the exception of falls. Among men, the most common cause of death is suicide in most cities except in Turin, where the most frequent cause are falls, and in Madrid, Lisbon and Kosice, where the most frequent cause of death are transport injuries. Among women, in most cities the most common cause of death are falls, except in Stockholm and Amsterdam, where the most frequent cause are suicides, and in Lisbon and Kosice, where the most frequent cause of death are transport injuries. In men, Helsinki and the cities of central eastern Europe have the highest mortality rates from all injuries. The cities of southern and central eastern Europe also have the highest mortality rates from transport injuries, while London and the southern cities show the lowest deaths rates from suicides. In women, the cities of southern and central eastern Europe, are characterized by the highest mortality rates from transport injuries, while Helsinki and western cities except London, show the highest mortality rates from homicides.

Figure 1 shows a selection of maps with different geographical patterns for mortality and deprivation in four cities of different parts of Europe. It shows that the spatial patterns for deprivation index and mortality due to drug overdose in Helsinki and London are similar, whereas the patterns for the deprivation index and mortality due to suicides in Lisbon are reversed. Finally, the pattern of mortality due to all injuries has no relationship with the deprivation index in Prague (maps for all causes and cities are found in: <https://www.ucl.ac.uk/ineqcities/atlas>).

Table 3 presents the association between the deprivation index and injury mortality in men. In general, the results show that in the cities of northern and western Europe, there is a positive association between the deprivation index and most causes of death, whereas no association is detected in the majority of central eastern European cities. Regarding all injury mortality there is an association significantly higher

than 1 with the deprivation index in most cities. The highest RR is obtained in Stockholm (RR=1.266, 95% CI: 1.220 to 1.313). In relation to specific causes of death, drug overdoses and homicides are the causes presenting the strongest significant positive associations with the deprivation index. In the case of drug overdoses, five cities show a significant positive association with the deprivation index; the two highest RRs are found in Stockholm with RR=1.541 (95% CI: 1.377 to 1.726) and in Helsinki with RR=1.383 (95% CI: 1.181 to 1.616). For homicides, seven cities present a significant positive association with deprivation index, the highest RR is found in Helsinki with RR=1.383 (95% CI: 1.061 to 1.779). Moreover, there is a significant positive association between the deprivation index and suicide mortality in seven cities, the highest RR corresponding to Stockholm (RR=1.224, 95% CI: 1.152 to 1.302). In the case of mortality due to transport injuries, there is a significant positive association in six cities, the highest RR corresponding to Stockholm (RR=1.175, 95% CI: 1.070 to 1.286). Finally, mortality due to falls only presents significant positive associations with the deprivation index in four cities, the highest RR are found in Lisbon (RR=1.190, 95% CI: 1.105 to 1.280).

Table 4 presents the association between the deprivation index and injury mortality in women. In general the RRs are smaller, and the associations are less often significant, than for men. The results show that in some cities of northern and western Europe there exists the most association between the deprivation index and causes of death, whereas no association is detected in the majority of southern and central eastern cities. Regarding all injury mortality there is an association significantly higher than 1 with the deprivation index in seven cities. The highest RR is obtained in Stockholm (RR=1.174, 95% CI: 1.122 to 1.227). In relation to specific causes of death, drug overdoses and homicides are the causes presenting the strongest significant positive association with the deprivation index. Four cities present a significantly positive association with the deprivation index for either of these causes. The highest significant RRs are found in Helsinki with RR=1.328, 95% CI: 1.122 to 1.571 for drug overdose and RR=1.449, 95% CI: 1.098 to 1.887 for homicides. In relation to suicide, a significant positive association with deprivation index is observed in Stockholm (RR = 1.183, 95% CI: 1.086 to 1.287), while Zurich (RR = 0.836, 95% CI: 0.782 to 0.892) and Lisbon (RR=0.904, 95% CI: 0.823 to 0.990) present negative associations. In the case of falls the only significantly positive association is in Rotterdam (RR = 1.088, 95% CI: 1.034 to 1.142) and with regard to transport injuries no significant association with the deprivation index is found in any of the cities studied.

## DISCUSSION

Socioeconomic inequalities in injury related mortality can be observed in the majority of the cities studied. These inequalities are more pronounced in men. Specifically, in the cities of northern and western Europe, socioeconomic inequalities in injury mortality are found for most of the specific causes studied. These inequalities are not significant in the majority of the cities of southern Europe in women and in the majority of the central eastern Europe in both sexes. With regard to specific causes, drug overdose and homicide are the causes presenting the strongest associations with the deprivation index, in both sexes, in the majority of the cities.

The present study reveals, apart from the existence of socioeconomic inequalities in injury related deaths, the variations in magnitude of these inequalities between cities situated in different regions of Europe. Although we are not aware of previous studies analyzing socioeconomic inequalities in injury related mortality in small areas within cities, there are studies which have analysed differences in injury mortality between countries. These studies have found that low and medium income countries (which include Hungary, Slovakia, and Czechia) have higher risks of death due to all types of injuries, with the exception of falls among women, compared to high income countries (Sethi, et al, 2006). Other studies have analysed mortality inequalities, in terms of educational level, for certain specific causes of injury in various European countries. These studies have found association between injury mortality and low educational level (Borrell, et al, 2005, Mackenbach, et al, 2008, Leinsalu, et al, 2009).

The differences in magnitude of the socioeconomic inequalities found between cities may be due to various reasons. On the one hand, it is important to point out that the cities studied present different physical, political, social and cultural environments which may affect the causes and determinants of injuries. Thus, for example, in some central eastern countries of Europe, the strategic investments in departments of public health needed to form effective responses to epidemics of chronic disease and injury that occurred in these countries during the middle of the 1990s, was minimal (Zatonski and HEM project team, 2011). On the other hand, the results show that socioeconomic differences seem to be greater where the injury mortality rates are lower. In addition, the results also show no significant associations in most cities in central eastern Europe, and this may be due to the lack of statistical power

due to the small number of geographic areas analysed in some cities in this region of Europe. Thus the absence of significant associations does not imply that the effect of deprivation on injury related mortality is negligible in these cities. In addition, the cities with small number of areas also have larger areas, and therefore are more homogeneous making the detection of inequalities difficult. In this sense, the variations in the deprivation index between city areas in central eastern Europe seem to be smaller than in other European cities. The deprivation index might be a better discriminator between areas in the cities of North, South and West of Europe than in the central east cities, and other contextual factors may be more relevant in the cities of this region.

Second, there may be differences between the cities in regard to coding of injuries in mortality registers. This fact could have consequences for the reliability of the data, since injuries may be under-reported in the mortality registries of some cities. Registration of these causes is a complex procedure which combines medical and legal aspects. Moreover, various authorities are involved in the procedures, which may vary between countries (Varnik, et al, 2010, Gotsens, et al, 2011b). For example, in the cases of injury death, in some countries, it is not obligatory to perform an autopsy and the legal authorities decide whether a forensic autopsy is necessary. This is the situation in the Netherlands, Belgium and Portugal. In contrast, in Hungary autopsies are performed in all cases of deaths due to injury. The low under-reporting of injuries in Hungarian mortality registers could explain why Budapest is the only city of central eastern Europe where socioeconomic inequalities have been detected for some causes. Another important aspect is the lack of communication between the person certifying the death and the legal authority in charge of the legal investigation. If this investigation produces a different decision about the cause of death, this information is not communicated to the certifier and the cause of death is not modified in the mortality statistics. This happens in the Netherlands and in Spain, for example (Varnik, et al, 2010, Gotsens, et al, 2011b).

In regard to the injury related mortality inequalities within a given city, our results agree with previous studies which have found that areas with worse socioeconomic indicators present higher all injuries mortality risk, and that the magnitudes of these inequalities are greater among men (Gotsens, et al, 2011a, Michelozzi, et al, 1999). Men, apart from being more exposed to suffering an injury, present more risky behaviours (driving fast, not using safety measures, higher consumption of alcohol and of drugs,

etc.) than women. These behaviours increase their risk of suffering disease, injury or death (Courtenay, 2000). It could be that the expression of masculinity mentioned above (worse behaviours among men) is more pronounced among those of deprived areas, a fact that might explain why the RR are higher among men than among women.

With regard to unintentional injuries, we have found socioeconomic inequalities in mortality from transport injuries in some cities in men. This agrees with some studies that have found that areas with worse socioeconomic indicators presented higher mortality risk related to traffic injuries (Laflamme, et al, 2009, Gotsens, et al, 2011a, Michelozzi, et al, 1999). More deprived areas might have poorer built environment and more infrastructure problems which can explain these inequalities. However, some studies conducted in cities of southern Europe have not found these inequalities (Esnaola, et al, 2006). In addition, some studies have found associations between mortality due to traffic injuries and physical and socioeconomic characteristics of the area where the injury occurred, which might be different from the area of residence (Haynes, et al, 2005, Jones, et al, 2008). In the case of drug overdose, some studies conducted in cities of southern Europe have found that areas with greater socioeconomic deprivation present higher mortality risks (Gotsens, et al, 2011a, Michelozzi, et al, 1999, Esnaola, et al, 2006). For falls, there are very few studies which have analysed socioeconomic inequalities in mortality for this cause at ecological level, and these studies did not find socioeconomic inequalities (Gotsens, et al, 2011a). The studies on falls often focus on children or the elderly, which are the most vulnerable groups.

In relation to intentional injuries, some studies have found that areas with greater socioeconomic deprivation present higher suicide mortality risks (Burrows, et al, 2010, Esnaola, et al, 2006, Chang, et al, 2011, Middleton, et al, 2006) and this would agree with our findings among men in the majority of the cities. In women, we only found a positive association with the deprivation index in Stockholm. Moreover, in Zurich and Lisbon we found an inverse relationship with the deprivation index. This divergence in direction of the association agrees with the findings of some review papers (Cubbin and Smith, 2002, Rehkopf and Buka, 2006). In the case of homicides, some studies conducted in the United States (Cubbin, et al, 2000), Brazil (Viana, et al, 2011), Great Britain (Shaw, et al, 2005) and Scotland (Leyland and Dundas, 2010) have reported a positive association between homicides and area

socioeconomic deprivation. However, it is important to note that few such studies have been conducted in European countries (Laflamme, et al, 2009).

#### *Limitations and strengths*

The main limitation of this study is the comparability of the data. In this regard there are considerable differences in numbers and sizes of the small areas in the different cities studied. This fact can have an influence in terms of low statistical power of the data to detect significant associations, especially in the cities of central eastern Europe. For this reason it is difficult to conclude on any substantial differences in patterns between central eastern cities and other cities. Moreover, although the deprivation index used in the study is comparable for all of the cities, it is important to note that for Amsterdam and Rotterdam the indicators used to elaborate the deprivation index are not based on a full population census. Finally, in some cities it was not possible to analyse all causes due to the small numbers of deaths observed in respect to the number of areas in each city.

The main strength of the study is that, to our knowledge, it is the first project to analyse inequalities in mortality due to all injuries, and to the leading injury related causes in 15 cities of different regions of Europe at small area level. In this sense, the processes occurring in urban areas are important factors to understand the economic, social, political and health transformations in a country. In addition, these cities have different socioeconomic contexts, something which provides a broad overview of the behaviour of these causes and lends consistency to the results found. Finally, studies of small areas are less susceptible to the ecological bias component created by heterogeneity within the exposure areas or other determining factors (Richardson, et al, 2004), and in addition permit detection of geographical patterns in mortality and deprivation which would not be evident with larger geographical areas.

#### CONCLUSIONS

This study confirms the existence of socioeconomic inequalities in injury related mortality, and highlights the differences in their magnitude between various cities from different regions of Europe, with differing socioeconomic context. Studies of this type may allow identification of geographical patterns and of areas with high mortality risk and poor socioeconomic indicators, which helps when developing interventions

aimed at reducing such inequalities. Furthermore, knowing that a health problem has a pattern of inequality is a first step to ensure that interventions aiming to address the problem will take these differences into account. For this reason, the researchers of INEQ-CITIES project have disseminated the results (Camprubi, et al, 2013) and have produced an atlas of inequalities in mortality in European cities, which is freely available online (<https://www.ucl.ac.uk/ineqcities/atlas>). However, despite growing awareness of the existence of socioeconomic inequalities in injury related mortality, not all European countries have developed policies to reduce them. Progress in this field requires strong political will, commitments in the long term and inter-sectorial collaboration with priority of creating safe environments (safer roads, safer night environments, better housing, etc.) (Borrell, et al, 2013, Comision Para Reducir Las Desigualdades Sociales En Salud En Espana, 2012). Moreover, the experience and knowledge generated in the different European countries may be used to identify and promote codes of good practice although, to be effective, interventions and programmes must be adapted to the context of each city.

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**Fig. 1** Distribution of deprivation index and smoothed Standardised Mortality Ratio (sSMR) for drug overdose in Helsinki and London, suicide in Lisbon and all injuries in Prague. White tones represent areas with mortality deficit or lower deprivation index, while those with excess mortality or higher deprivation index are represented with black tones. Men and women

**Table 1** Number of small areas, population year, total population and distribution of population and the deprivation index in each city.

Europe an Region	City/Region	Number of areas	Year	Total population			Deprivation index			
				Total	P <sub>25</sub>	P <sub>50</sub>	P <sub>75</sub>	P <sub>25</sub>	P <sub>50</sub>	P <sub>75</sub>
North	Helsinki	94	200	542,701	2962	4962	7965	3.	4.	5.
	Stockholm	117	200	1,864,3	487	1202	2193	2.	3.	4.
West	London	633	200	7,172,0	10,07	11,33	12,76	6.	7.	9.
	Amsterdam	94	200	738,325	3518	7582	11,51	4.	6.	8.
	Rotterdam	88	200	600,022	867	6595	10,54	4.	6.	9.
	Zurich	212	200	364,977	959	1618	2288	4.	6.	7.
	Brussels Region	118	200	970,037	5767	7779	10,62	5.	7.	9.
South	Turin	266	200	892,157	184	274	413	5.	6.	7.
	Madrid	235	200	3,149,6	996	1239	1524	5.	7.	9.
	Barcelona	149	200	1,588,4	788	974	1225	5.	7.	8.
	Lisbon	207	200	2,661,8	4123	9738	17,62	4.	5.	6.
Centra	Budapest	23	200	1,705,3	58,39	76,97	91,10	5.	6.	7.
	Košice	22	200	235,241	1238	3373	22,70	5.	6.	7.
	Bratislava	17	200	425,156	2354	18,72	34,59	3.	4.	4.
	Prague	57	200	1,170,5	1768	3197	27,21	4.	4.	4.

P<sub>25</sub> = percentile 25

P<sub>50</sub> = percentile 50 (median)

P<sub>75</sub> = percentile 75

**Table 2** Number of deaths (n) and crude mortality rate (MR) per 100,000 inhabitants by cause of death in men and women for each city.

Europe	City/Region	Period	Transport injury		Drug overdose		Falls		Suicide		Homicide		All injuries	
			n	MR	n	M	n	M	n	M	n	M	n	MR
Men	Nor	Helsinki 2000	20	8.1	2	10	6	25	7	30	7	2.	26	10
		Stockholm 2000	49	6.7	3	4.	5	7.	1	15	1	1.	44	60.
	We	London 2000	19	6.2	1	5.	1	4.	2	7.	2	0.	12,	39.
		Amsterdam 1996	27	5.8	1	2.	3	7.	8	18	2	4.	23	49.
		Rotterdam 1996	27	7.2	1	2.	2	5.	5	15	1	4.	17	46.
		Zurich 2000	86	5.3	1	9.	3	19	4	29	2	1.	11	72.
	Brussels 2001	89	4.7	5	2.	1	7.	3	16	5	2.	90	47.	
	Sou	Turin 1996	53	14.	1	4.	5	14	4	10	4	1.	20	53.
		Madrid 2000	11	9.7	1	1.	4	3.	7	6.	2	2.	43	38.
		Barcelona 2000	58	8.7	3	5.	4	6.	7	10	8	1.	34	51.
Lisbon 1995		44	25.	3	1.	9	5.	2	13	5	3.	12,	69.	
Cen	Budapest 2001	97	15.	1	1.	1	28	1	29	1	2.	57	92.	
	Košice 2000	22	21.	2	0.	1	11	1	18	2	2.	93	91.	
	Bratislava 2000	32	17.	5	2.	2	13	3	20	8	4.	15	85.	
	Prague 2003	33	11.	2	0.	4	14	6	21	4	1.	21	77.	
Wo	N	Helsinki 2000	77	2.6	1	4.	5	20	3	13	4	1.	15	53.
		Stockholm 2000	15	2.0	8	1.	4	6.	6	8.	5	0.	28	36.
	W	London 2000	68	2.0	4	1.	1	3.	9	2.	9	0.	63	19.
		Amsterdam 1996	12	2.6	5	1.	4	8.	4	8.	8	1.	17	36.
		Rotterdam 1996	11	2.8	2	0.	2	6.	2	5.	5	1.	13	33.
		Zurich 2000	48	2.8	7	4.	4	27	3	20	2	1.	10	62.
		Brussels 2001	40	1.9	1	0.	1	9.	1	9.	3	1.	82	40.
	S	Turin 1996	18	4.4	3	0.	9	21	1	4.	3	0.	16	38.
		Madrid 2000	42	3.3	4	0.	5	4.	3	2.	9	0.	25	19.
		Barcelona 2000	26	3.4	9	1.	5	7.	3	4.	4	0.	26	35.
Lisbon 1995		15	8.0	4	0.	7	4.	8	4.	1	1.	54	28.	
Cen	Budapest 2001	48	6.4	3	0.	2	35	1	13	9	1.	49	66.	
	Košice 2000	81	7.3	1	0.	4	4.	5	4.	9	0.	31	28.	
	Bratislava 2000	13	6.4	1	0.	1	6.	6	3.	2	1.	55	26.	
	Prague 2003	15	5.0	12	0.	62	20	21	6.	2	0.	14	47.	

**Table 3** Association between mortality and the deprivation index. Men

European Region	City/Region	Transport Injury		Drug overdose		Falls		Suicide	
		RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
North	Helsinki	1.013	(0.890 - 1.148)	1.383	(1.181 - 1.616)	1.121	(1.034 - 1.210)	1.164	(1.077 - 1.258)
	Stockholm <sup>a</sup>	1.175	(1.070 - 1.286)	1.541	(1.377 - 1.726)	1.087	(0.998 - 1.183)	1.224	(1.152 - 1.302)
West	London	1.045	(1.019 - 1.072)	1.061	(1.021 - 1.103)	1.021	(0.985 - 1.057)	1.040	(1.015 - 1.067)
	Amsterdam	1.045	(1.004 - 1.088)	1.057	(0.968 - 1.155)	0.969	(0.929 - 1.010)	1.024	(0.987 - 1.064)
	Rotterdam	1.045	(1.002 - 1.091)	1.223	(1.122 - 1.339)	1.067	(1.005 - 1.128)	1.063	(1.029 - 1.098)
	Zurich	1.090	(0.968 - 1.219)	1.116	(0.988 - 1.245)	0.971	(0.903 - 1.041)	1.014	(0.957 - 1.072)
	Brussels Region	1.061	(0.995 - 1.128)	1.069	(0.983 - 1.158)	1.035	(0.983 - 1.087)	0.984	(0.942 - 1.025)
South	Turin <sup>a</sup>	1.032	(0.991 - 1.074)			1.041	(0.997 - 1.086)	1.006	(0.958 - 1.053)
	Madrid <sup>a</sup>	1.052	(1.025 - 1.079)			1.015	(0.971 - 1.060)	1.042	(1.007 - 1.078)
	Barcelona <sup>a</sup>	1.028	(0.983 - 1.075)	1.190	(1.122 - 1.260)	1.040	(0.992 - 1.088)	1.066	(1.031 - 1.102)
	Lisbon Metropolitan Area	1.072	(1.017 - 1.130)	1.095	(0.960 - 1.247)	1.190	(1.105 - 1.280)	1.052	(0.984 - 1.123)
Central east	Budapest	1.024	(0.949 - 1.099)	1.174	(0.824 - 1.661)	1.132	(1.040 - 1.234)	1.090	(1.029 - 1.158)
	Košice <sup>a</sup>	0.985	(0.894 - 1.067)			1.021	(0.876 - 1.148)	0.972	(0.852 - 1.077)
	Bratislava	1.040	(0.751 - 1.421)	0.662	(0.281 - 1.198)	1.156	(0.850 - 1.514)	1.120	(0.835 - 1.472)
	Prague <sup>a</sup>	0.925	(0.352 - 2.079)			0.668	(0.271 - 1.368)	1.222	(0.650 - 2.133)

RR: relative risk

95% CI: credible interval at 95%

<sup>a</sup> Due to the small numbers of deaths in respect to the number of areas in each city some causes have not been analysed**Table 4** Association between mortality and the deprivation index. Women

European Region	City/Region	Transport Injury		Drug overdose		Falls		Suicide	
		RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
North	Helsinki	1.038	(0.843 - 1.261)	1.328	(1.122 - 1.571)	0.966	(0.897 - 1.039)	1.084	(0.986 - 1.194)
	Stockholm <sup>a</sup>	0.975	(0.821 - 1.149)			1.024	(0.930 - 1.123)	1.183	(1.086 - 1.287)
West	London	0.990	(0.956 - 1.026)	1.075	(1.015 - 1.138)	1.029	(0.987 - 1.073)	1.021	(0.980 - 1.063)
	Amsterdam	1.013	(0.948 - 1.086)	0.977	(0.879 - 1.084)	0.996	(0.953 - 1.041)	1.022	(0.974 - 1.073)
	Rotterdam	1.037	(0.970 - 1.106)	1.253	(1.047 - 1.500)	1.088	(1.034 - 1.142)	0.986	(0.927 - 1.044)
	Zurich	1.119	(0.952 - 1.303)	1.229	(1.078 - 1.391)	0.977	(0.904 - 1.052)	0.836	(0.782 - 0.892)
	Brussels Region	1.003	(0.901 - 1.103)	0.981	(0.827 - 1.134)	1.006	(0.944 - 1.068)	0.975	(0.926 - 1.023)
South	Turin <sup>a</sup>	1.035	(0.966 - 1.105)			1.013	(0.981 - 1.044)	0.981	(0.909 - 1.056)
	Madrid <sup>a</sup>	1.001	(0.961 - 1.042)			0.981	(0.942 - 1.020)	0.976	(0.927 - 1.029)
	Barcelona <sup>a</sup>	0.969	(0.914 - 1.024)			1.001	(0.957 - 1.046)	0.960	(0.908 - 1.015)
	Lisbon Metropolitan Area	0.990	(0.923 - 1.060)	1.215	(0.896 - 1.627)	1.036	(0.965 - 1.113)	0.904	(0.823 - 0.990)
Central east	Budapest	1.019	(0.917 - 1.132)	1.223	(0.788 - 1.893)	1.067	(0.981 - 1.161)	1.088	(0.983 - 1.209)
	Košice <sup>a</sup>	1.042	(0.910 - 1.162)			0.833	(0.452 - 1.185)	0.926	(0.633 - 1.186)
	Bratislava	0.802	(0.495 - 1.210)	2.056	(0.616 - 5.088)	0.784	(0.508 - 1.111)	1.237	(0.688 - 2.067)
	Prague <sup>a</sup>	0.782	(0.212 - 2.001)			1.217	(0.615 - 2.146)	1.537	(0.577 - 3.348)

RR: relative risk

95% CI: credible interval at 95%

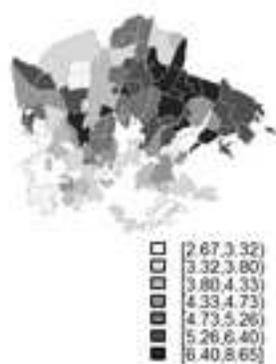
<sup>a</sup> Due to the small numbers of deaths in respect to the number of areas in each city some causes have not been analysed

Highlights:

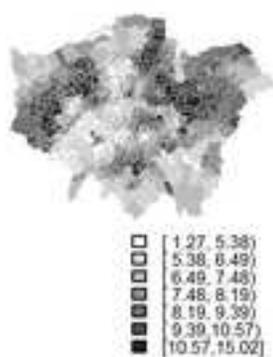
- Socioeconomic inequalities exist in injury mortality at small area level in most European cities.
- There are differences in the magnitude of these inequalities.
- Intersectorial collaboration is necessary to create safe environments.

Accepted manuscript

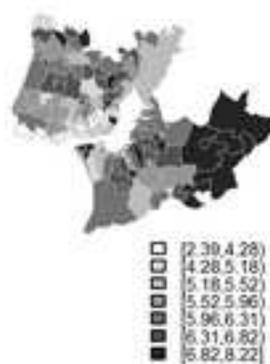
**HELSINKI**  
Deprivation index



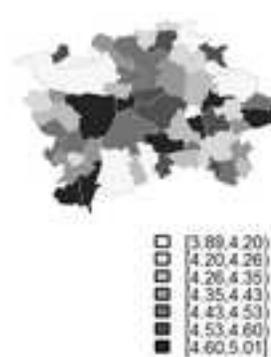
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Deprivation index



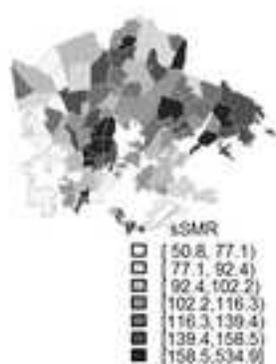
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Deprivation index



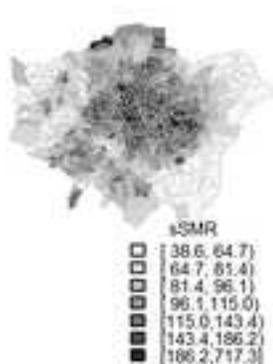
**PRAGUE**  
Deprivation index



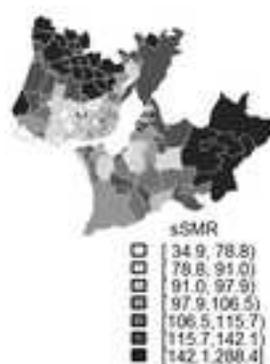
**Drug overdose, men**



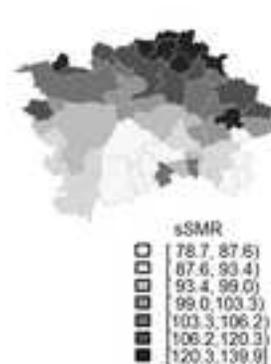
**Drug overdose, men**



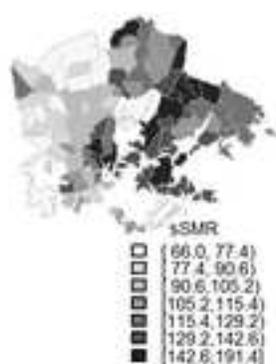
**Suicide, men**



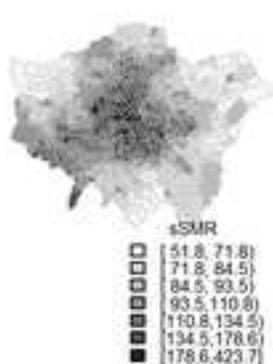
**All injuries, men**



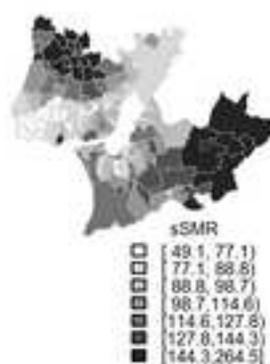
**Drug overdose, women**



**Drug overdose, women**



**Suicide, women**



**All injuries, women**

