

Housing, income inequality and child injury mortality in Europe: a cross-sectional study

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Abstract

Background Child poverty rates are compared throughout Europe to monitor how countries are caring for their children. Child poverty reduction measures need to consider the importance of safe living environments for all children. In this study we investigate how European country-level economic disparity and housing conditions relate to one another, and whether they differentially correlate with child injury mortality.

Methods We used an ecological, cross-sectional study design of 26 European countries of which 20 high-income and 6 upper-middle-income. Compositional characteristics of the home and its surroundings were extracted from the 2006 European Union Income Social Inclusion and Living Conditions Database ($n = 203\,000$). Mortality data of children aged 1–14 years were derived from the World Health Organization Mortality Database. The main outcome measure was age standardized cause-specific injury mortality rates analysed by income inequality and housing and neighbourhood conditions.

Results Nine measures of housing and neighbourhood conditions highly differentiating European households at country level were clustered into three dimensions, labelled respectively housing, neighbourhood and economic household strain. Income inequality significantly and positively correlated with housing strain ($r = 0.62$, $P = 0.001$) and household economic strain ($r = 0.42$, $P = 0.009$) but not significantly with neighbourhood strain ($r = 0.34$, $P = 0.087$). Child injury mortality rates correlated strongly with both country-level income inequality and housing strain, with very small age-specific differences.

Conclusions In the European context housing, neighbourhood and household economic strains worsened with increasing levels of income inequality. Child injury mortality rates are strongly and positively associated with both income inequality and housing strain, suggesting that housing material conditions could play a role in the association between income inequality and child health.

Keywords

child health, Europe, housing conditions, income inequality

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Background

In the European Union children are more at risk of poverty than the general population, ranging from 9–10% in Nordic countries to almost 25–30% in Eastern European countries (European Commission 2008). Numerous country-level studies highlight the adverse effect of material deprivation on child

health, in Europe and other settings (Kaplan *et al.* 1996; Hales *et al.* 1999; Mielck *et al.* 2002; Ram 2005; Collison *et al.* 2007; Dorling *et al.* 2007; Pickett & Wilkinson 2007; Singh & Kogan 2007; Wilkinson & Pickett 2008; Kondo *et al.* 2009). Child poverty rates are used throughout Europe to monitor how countries are caring for their children. Yet there has recently been a policy shift to move away from a focus on a single

income-driven measure towards capturing the multidimensional nature of children's lives (Bradshaw & Richardson 2009; OECD 2009). Measures include, for example, material well-being, educational productivity, social relationships and the housing environment (UNICEF 2007). The aim of using the concept of child well-being is to stimulate policy development not only for child poverty reduction, but also for the improvement of safe and healthy living environments for all children.

Housing is of particular importance in child well-being as it acts as a key determinant of health through a range of direct and indirect pathways at the individual, household and area level (Shaw 2004). The home is where young children grow up and achieve developmental milestones by interacting with their physical and social surroundings. Young children are dependent on caregivers for the safety of their environment, which is mainly created for adults. Common paediatric conditions such as obesity, asthma, lead poisoning and injuries are associated with risk factors within a child's built environment (Cummins & Jackson 2001; Shenassa *et al.* 2004; Lyons *et al.* 2006; Braubach *et al.* 2011). In addition, substandard housing has been shown to create psychosocial stressors undermining health and contributing to delayed cognitive development, disability (Harker 2006) and behavioural problems among children (Krieger & Higgins 2002). At the neighbourhood level the direct health effect stems from living in a deprived neighbourhood (Graham & Stephens 2008; Gagné & Hamel 2009), and examples of indirect effects are the density of off-premise alcohol outlets (Freisthler *et al.* 2008) and availability and accessibility of health services (Dunn *et al.* 2005), or recreational facilities (Veitch *et al.* 2008).

The state and condition of housing is regarded as a mechanism through which deprivation affects health in the population (Shaw 2004). This study concerns the European context, a region where there are wide economic disparities across and between countries, and specifically addresses the following three questions:

- 1 How do income inequality and housing/neighbourhood conditions relate to one another at country level?
- 2 How do income inequality and housing/neighbourhood conditions relate to injury mortality in children?
- 3 Are there age-specific differences in the correlation between income inequality and housing/neighbourhood conditions?

Methods

Study design

This is an ecological, cross-sectional country-level study including 26 European countries. Housing and neighbourhood

conditions were extracted from the European Union Income, Social Inclusion and Living Conditions Database (EU SILC), a multipurpose instrument to provide comparative statistics on income distribution and social exclusion in the European Union (Eurostat 2006). The following European Member States participating in the survey in 2006 were included, representing both high-income [Austria, Belgium, Cyprus, Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Iceland (special status country), Italy, Luxembourg, the Netherlands, Norway (special status country), Portugal, Sweden, Slovenia, Spain, the UK] and upper-middle-income (Estonia, Hungary, Lithuania, Latvia, Poland, Slovakia) countries as defined by the World Bank according to gross national income per capita. A specific sample size was achieved in each country based on its population in accordance with the EU SILC survey requirements of Eurostat. Data collection was flexible, with interviews being conducted in 19 countries via paper-assisted personal interview, computer-assisted personal interviews and computer-assisted telephone interviews. The remaining seven countries extracted most or part of the information from administrative data, gathered from national registers: Denmark, the Netherlands, Slovenia, Finland, Sweden, Iceland and Norway. The total number of households contributing information in the countries under study was approximately 203 000. For detailed information about the EU SILC see the Eurostat website http://epp.eurostat.ec.europa.eu/portal/page/portal/income_social_inclusion_living_conditions/introduction.

Income inequality was used as a measure to represent the effect of living in more unequal countries, as country income differences have been suggested to be relevant to health in rich countries (Pickett & Wilkinson 2007). Data on income inequality for the 26 European countries were obtained from Eurostat (http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Social_inclusion_statistics#Income_inequalities) as the ratio of total income received by the 20% of the population with the highest income, to that received by the 20% of the population with the lowest income. All incomes were compiled as equivalized disposable incomes, representing the total income of a household, after tax and other deductions and available for spending or saving, divided by the number of household members converted into equalized adults (household members are equalized or made equivalent by weighting each according to their age).

Injury deaths of children 1–14 years were chosen as the outcome variable as they are available for a wide range of European countries and represent both the most severe health outcome and one that is more easily comparable across

countries. The data were drawn from the World Health Organization Mortality Database online (WHOSIS, <http://www.who.int/whosis/mort/download/en/index.html>) to calculate 2006 age-standardized mortality rates, except for four countries [Belgium (2004), Ireland (2007), Portugal (2003), Slovakia (2005)] that did not have 2006 data in International Classification of Diseases – the Tenth Revision (ICD 10) format available for that year. From among all child mortality causes, injury (road traffic, drowning, poisoning, thermal injuries, etc.) rates were retained as they represented approximately one-third of the mortality burden of disease (World Health Organization 2008).

Data treatment

In order to determine how country-level housing conditions can be characterized we first identified variables from the EU SILC database that depicted housing, neighbourhood and household economic conditions. These included variables with known socio-economic differences within countries such as dwelling type, rental/owner status, house size/type as well as housing problems, e.g. leaking roof, pollution, crime and ability to keep home warm. Also, descriptors of the economic conditions of the households were taken into consideration, including, e.g. owning a computer/television/mobile phone, capacity to face unexpected expenses and housing costs, and gross/disposable household income. After a run through of the household-level data, 40 variables were retained that could give a broad picture of the potential sources of differential housing conditions between countries. Next we had a closer look at the frequencies of selected variables that differentiated between the

countries under study. For the variables with multiple responses (e.g. number of rooms) or monetary responses (e.g. total household disposable income) we grouped the distribution into categories (e.g. two to four rooms, five to six rooms or disposable income 0–10,000€, 10,000–20,000€, 20,000€ and above). This was followed by the exclusion of redundant variables by looking more closely at how correlated the variables were with one another. Spearman's rank and Pearson correlation coefficients ranging from 0.8 to 1.0 were excluded from further analysis. This overall selection process resulted in 11 country-level variables discriminating the countries under study (see Table 1).

Next, we analysed how these variables clustered by means of an exploratory factor analysis using the principal component method, varimax with Kaiser normalization (SPSS Version 18.0). Factor scores were estimated by creating linear composites of the observed variables, i.e. factor scores were computed by adding together the country levels' optimally weighted scores on each of the observed variables. The pattern matrix of the first three factors resulting from the factor analysis are shown in Table 2 (together explaining 55% of the variance) where the variables contributing most importantly to the formation of each the factor (loading > 0.50) are indicated in bold. Nine variables out of 11 significantly loaded on these three factors.

Each factor emphasizes various types of household strains and they were labelled as follows. Factor 1 received the more general label of 'housing strain' to underline the variety of material sources of strain and their relation to housing. Factor 2, 'neighbourhood strain' reflected the disadvantage found in the local housing environment. Factor 3 was labelled 'household economic strain' to reflect the variables representing the direct

Table 1. Descriptors of the living condition variables employed

Variable	Description	Mean	Std	Minimum	Maximum
Inability to keep home adequately warm	Proportion of households unable to keep home warm	11.0	12.1	1.3	45.7
Leaking roof, damp walls/floors/foundation, or rot in window frames or floor	Proportion of households with a structural housing problem	18.5	9.3	4.4	41.9
Ability to make ends meet	Difficulty experienced by the household in making ends meet	53.1	24.0	14.1	85.5
Capacity to face unexpected financial expenses	Proportion of households without this capacity	34.5	14.7	13.0	74.4
Noise from neighbours or from the street	Proportion of households with neighbourhood noise problem	20.8	5.4	12.2	35.8
Pollution, grime or other environmental problems	Proportion of households with environmental problem	15.6	5.9	7.0	31.7
Crime, violence or vandalism in the area	Proportion of households with crime, violence or vandalism problem	13.2	5.4	2.3	26.9
Total disposable household income	The proportion of households with a total disposable household income ranging from 0 to 10,000€	24.8	31.4	0.5	86.2
Total housing cost	Proportion of households with a total housing cost ranging from 0 to 300€	55.4	35.2	2.4	99.8
Tenure status	Proportion of households with rental owners	18.1	11.0	1.9	38.5
Household type	Proportion of households with two parents and three or more dependent children	5.1	3.1	0.9	14.3

Table 2. Pattern matrix from the factor analysis with factor loading values > 0.50 in bold

	Factor 1: housing strain	Factor 2: neighbourhood strain	Factor 3: household economic strain
Inability to keep home adequately warm	0.617	−0.014	0.028
Leaking roof, damp walls/floors/foundation, or rot in window frames or floor	0.522	0.175	−0.004
Ability to make ends meet	0.642	0.021	0.326
Capacity to face unexpected financial expenses	0.775	0.009	0.088
Noise from neighbours or from the street	0.080	0.767	−0.015
Pollution, grime or other environmental problems	0.025	0.777	0.100
Crime, violence or vandalism in the area	0.107	0.614	−0.077
Total disposable household income	0.345	−0.006	0.780
Total housing cost	0.022	−0.009	0.903
Tenure status	0.121	0.056	0.027
Household type	0.230	0.085	0.082

monetary housing costs. The correlations between factors were 0.26 for Factors 1 and 2, 0.49 for Factors 1 and 3, and 0.19 for Factors 2 and 3. The correlation between Factors 1 and 3 is the highest one, most likely as the two factors include monetary/economic – but distinct – aspects.

In order to answer our research questions Pearson coefficient correlations were measured (SPSS Version 18.0) to assess the relationship between these strains and income inequality at country level and the effect on age-specific child injury mortality, with a focus on the housing and neighbourhood strains.

Results

Country-level income inequality and housing/neighbourhood conditions

In order to respond to the first research question, Fig. 1 shows income inequality significantly correlated at country level with the housing strain ($r = 0.62$, $P = 0.001$) and the household economic strain ($r = 0.42$, $P = 0.009$), but not significantly with the neighbourhood strain ($r = 0.34$, $P = 0.087$). The steepest gradient is between income inequality and household economic strain, which also shows the greatest dispersion at any given level of income inequality. All three strains tend to be higher in the countries with greater levels of income inequality (Latvia, Lithuania, Greece, Portugal) as compared with more equal countries (Sweden, Denmark, Finland, the Netherlands).

Country-level income inequality, housing/neighbourhood conditions and child injury mortality

At country level injury mortality rates for children 1–14 years significantly and positively correlate with income inequality and

housing strain, but not for neighbourhood strain (Fig. 2a–c). Also, high dispersion is seen in injury mortality rates as the income or the housing inequality gap increases among the European countries.

Does age matter?

When the 26 countries were aggregated Fig. 3a indicates child injury mortality rates show a higher correlation with housing strain than with income inequality, although positive in both cases, with very small age-specific differences. In contrast, Fig. 3b shows greater dispersion across ages and a higher correlation with income inequality than with the neighbourhood strain.

Discussion

Main findings

Our findings show that in all 26 European countries considered the country-level housing, neighbourhood and household economic strains worsened with increasing levels of income inequality. This can lead one to think that housing conditions are not only an important determinant of child health, but also a likely mechanism of influence in the relationship between income inequality and child safety and health. A plausible explanation is that in countries with higher levels of income equality, children have a more unequal access to safe housing.

The results are in line with previous findings showing housing deprivation is a mechanism affecting population health (Thomson *et al.* 2001; DiGuseppi *et al.* 2010; Jacobs *et al.* 2010). Housing and neighbourhood conditions, although measured in different manners, have been shown to have

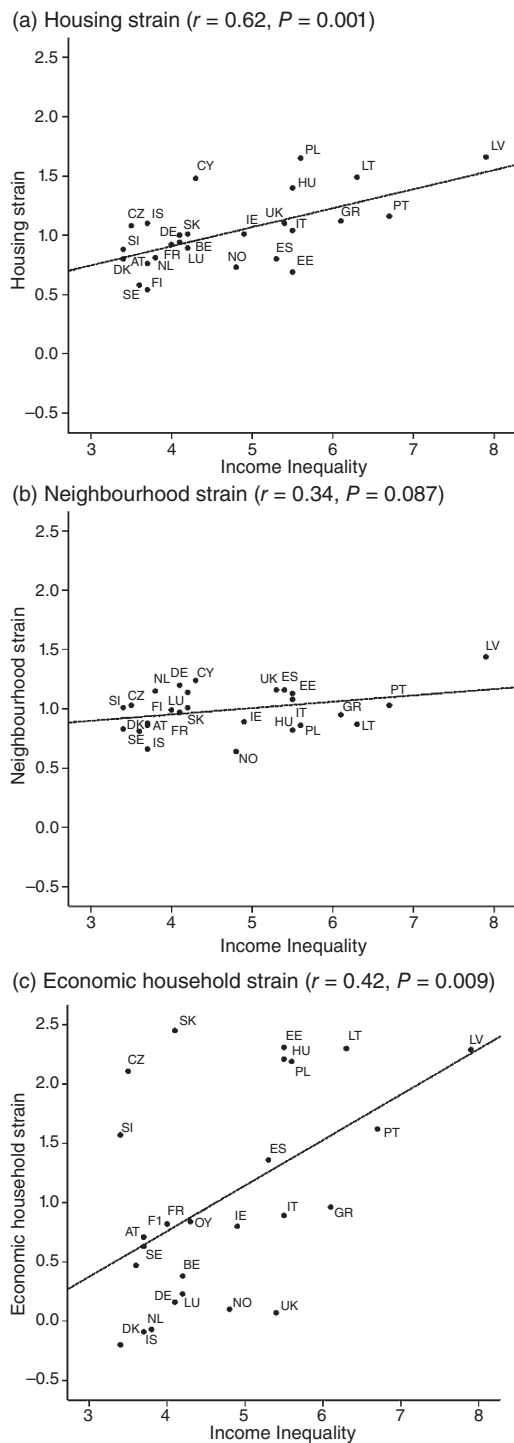


Figure 1. Association between income inequality (20:20 ratio) and housing conditions in 26 European countries. AT, Austria; BE, Belgium; CY, Cyprus; CZ, Czech Republic; DK, Denmark; EE, Estonia; FI, Finland; FR, France; DE, Germany; ES, Spain; HU, Hungary; IE, Ireland; IT, Italy; IS, Iceland; LV, Latvia; LT, Lithuania; LU, Luxembourg; MT, Malta; NO, Norway; NL, the Netherlands; PL, Poland; PT, Portugal; SK, Slovakia; SI, Slovenia; SE, Sweden; UK, United Kingdom.

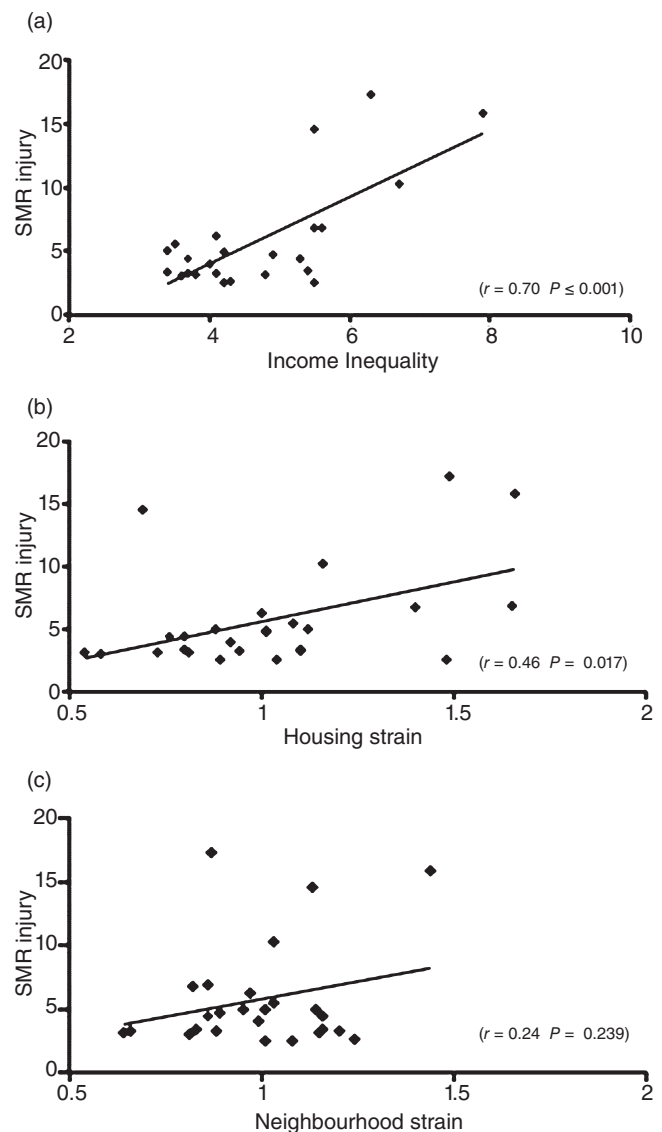


Figure 2. Injury mortality gradients among children 1–14 years by income inequality (a), housing strain (b), neighbourhood strain (c). SMR, standardized mortality ratio.

independent effects on health at the local area (Gibson *et al.* 2011). One study in eight European cities demonstrated that inadequate housing affected the general health and well-being of the residents, even when controlling for poverty and socio-economic status (Ormandy 2009). Quantifying the environmental burden of disease related to housing factors in deaths and disability-adjusted life years is taking place at the European level (World Health Organization 2006; Braubach *et al.* 2011) through the selection of a core set of health inequality indicators related to housing, environmental exposure, and home injuries

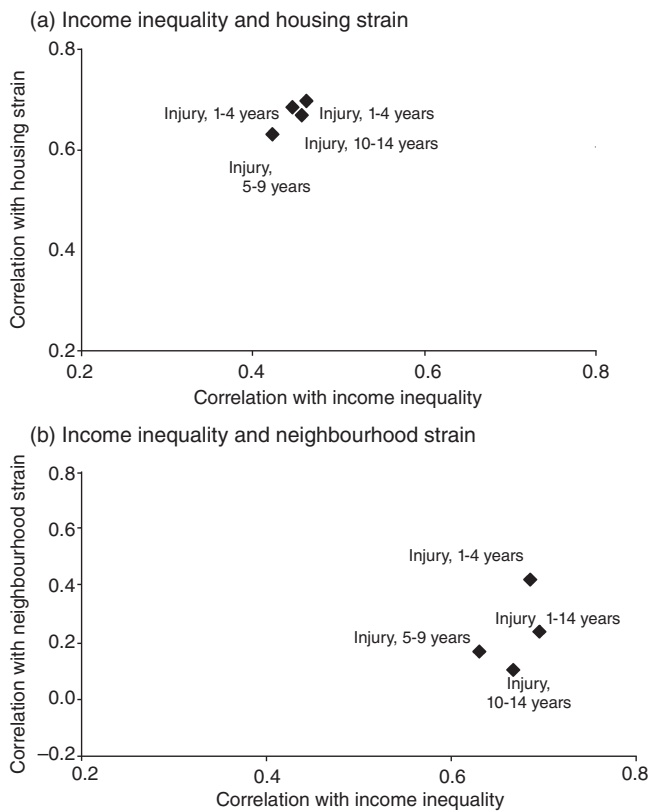


Figure 3. Cross-country age-specific cause of mortality with income inequality and housing strain (a) and neighbourhood strain (b).

in each country (World Health Organization 2011). This is being undertaken in order to formulate policy to counter the effect of social inequalities on environmental health (World Health Organization 2010).

In all age groups approximately one in three injuries occur in the home environment and among children under the age of five, over half of the non-fatal injuries (Bauer & Steiner 2009). This study indicates that at country-level child injury mortality relates more strongly to housing strain than to income inequality, with negligible child age-specific differences observed. Addressing child injuries in Europe is a necessity as injuries have the steepest social gradient of all causes of childhood mortality and socio-economic disparities exist at all levels of severity (Laflamme *et al.* 2010). They are also highly preventable: three out of four lives could be saved if all European countries had the same mortality rate as that of the lowest countries (Sethi *et al.* 2008), particularly injuries to very young children occurring in the home environment (Towner *et al.* 2001; Kendrick *et al.* 2005). In light of this study, there is additional suggestive evidence that improving housing conditions is a potential means of reducing country-level mortality for children of all ages.

Limitations

The use of cross-nationally comparable data on the composition of household incomes, housing conditions and child outcomes from 26 Member States provides a comprehensive picture of European households. Yet the data sources do suffer from a number of limitations. EU SILC data are collected by surveys, registers or a combination of both and there is concern that this difference in sources may account for measured differences, especially as Nordic countries tend to use registers and also have lower levels of income inequality and relative poverty; Eurostat recognizes that there is a need for systematic assessment of EU SILC comparability with external sources, particularly on the income variables of the kind that were not the main focus of this study (Eurostat 2007). The household response rate was high (ranged from 61% to 95% with the 26 country average at 80%) and we have no reason to believe that substantial differences would arise between countries regarding the self-reported data on the housing variables we selected. These variables were used to discriminate between countries regarding sources of differences. Yet, we cannot determine the relative importance of each of the single variables selected – or that of the factors obtained – regarding its capacity to impoverish the quality of the housing conditions as no such weighing was applied. Also, the EU SILC covers only private households and within this group vulnerable groups may be under-represented as they are hard to reach. Furthermore, no child-specific items were included in the EU SILC 2006 data; therefore, we may not have captured material deprivation measures specific to children's life conditions that may be different from their parents. Nonetheless, the EU SILC remains the key source for measures of income, housing, labour information and social exclusion because of its adherence to data quality guidelines and procedures aimed at maximizing comparability at the European Union level, as documented by Eurostat (Eurostat 2009).

The World Health Organization mortality data are the best estimates available presently for cross-national data, yet there may exist national differences in coding practices. In addition, the analysis was limited by the lack of data on potentially important co variables, such as national regulations on housing in the countries under study, which are difficult to identify as they often exist at the regional and provincial level rather than at the national level in many European countries. Also, as the outcome measures were aggregated it was not possible to explore differences within these broad categories of mortality burden. It would be of interest to investigate specific health outcomes within injury.

Lastly, in addition to housing and neighbourhood conditions examined in this study, other intermediary mechanisms may come into play that was not considered in this study. For instance the psychosocial stress related to lower socio-economic status in more deprived households (Marmot & Wilkinson 2001) and the consequences that it might have on child safety (through lower safety thresholds or on parenting skills). This, if present, may have an aggravating effect on poor living conditions.

Implications and future studies

Research has made clear that the relationship between child health disparities and economic disparities is not inevitable, but policy amenable (UNICEF 2007). The European Commission has a mandate to co-operative action at the European level. A home safety action plan in Europe is needed to commit to a collaborative, multisectoral effort to address the issue of home safety. Such an initiative exists for road safety at the global and European level (Road Safety Action Plan 2001–2010, 2011–2020). For all ages the burden of home injuries has been shown to be greater than that of road injuries, with fatal unintentional home injuries more than twice the rate of road fatalities (KfV 2009) and a national estimate found that home injuries cost 3.5 times more than road injuries (Keall *et al.* 2011). Therefore the same, if not more, resources should be allocated to home safety. This Programme would assist countries: (1) in creating comprehensive packages of policies and interventions related to housing investment (Thomson *et al.* 2001; DiGuseppi *et al.* 2010); and (2) to assess housing quality in a systematic and standardized manner throughout Europe in order to accurately estimate the environmental burden of disease and injury related to housing. Measures of potential lives saved must be combined with the costs of inadequate housing to society (in the UK the cost is estimated at over €744 million a year), as well as the financial savings to the health sector from housing investment (Audit Commission 2009; Roys *et al.* 2010). Also, multilevel analyses are needed to quantify the differential meaning of housing-related factors at the individual, household and country level. This will require collaboration with sectors outside of the public health sector. A safe and healthy environment is a child's fundamental right.

Conclusion

In the European context housing, neighbourhood and household economic strain strains worsened with increasing levels of income inequality. Child injury rates are strongly and positively

associated with both income inequality and housing strain. The findings provide suggestive evidence that tackling differences in housing conditions at country level within and between European countries may mitigate the negative consequences of income inequality on child health and safety.

Key messages

- Child injury rates are strongly and positively associated with both income inequality and housing strain.
- Tackling country-level housing differentials could assist both in child injury prevention and in the reduction of social inequality in child safety and health.

Competing interests

The authors have no competing interests to declare.

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