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CHILD INJURY IN EUROPE

**Scope, circumstances and association
with country-level housing conditions
and economic disparities**

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Institutet**

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Child injury in Europe - scope, circumstances and association with country-level housing conditions and economic disparities

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ABSTRACT

Background: Injuries are a major cause of social inequality in child health in Europe and the leading cause of mortality. There is a need for information to assist in developing a coordinated policy action to tackle these problems.

Aims: This thesis aims to increase knowledge about child home injuries in the European context and the role played by housing conditions at country level in the association between country economic level and income disparity and child safety.

Methods: Four cross-sectional register-based studies were conducted, three of which at country level. Injury incidence and patterns were described using data from the EU Injury Database for children ages 0 to 18 years (6 countries). The WHO Mortality Database served to estimate injury cause-specific mortality rates in children ages 0 to 14 years (16 countries). Compositional characteristics of the home and its surroundings were extracted from the 2006 European Union Income Social Inclusion and Living Conditions Database. Three types of country-level housing strains (9 variables) were identified and their role was assessed in relation to country economic level/income inequality and child mortality (26 countries).

Results: The crude annual incidence of emergency department-attended child non-fatal home injuries for 0-18 years based on an average of six European countries was estimated at 44.9 (95% CI 29.1-60.7) per 1,000 inhabitants, with the incidence peaking at one to two years. The characteristics of these injuries fit into six consistent and distinctive clusters (Article I). Fatal home injuries in 16 European countries were highest in children under five years of age and the majority of the upper middle income countries tended to have higher rates than the high income countries. In all countries aggregated data showed that drowning, fire, poisoning, falls and homicide accounted for almost 90% of all home injury deaths (Article II). At country-level, income inequality positively correlated with housing strain ($r=0.62$, $p=0.001$) and economic household strain ($r=0.42$, $p=0.009$), but not with neighbourhood strain ($r=0.34$, $p=0.087$). All three strains tended to be worse in countries with higher income disparities and injury mortality rates correlated more strongly with country level housing strain than income inequality (Article III). Housing conditions significantly contributed to explain the association between both country economic level and country income inequality and child mortality (all causes or all injury causes). Adjusting for housing and neighbourhood strain respectively increased the association between country economic level and child mortality for most mortality causes (Article IV).

Discussion: In upper middle- and high-income countries of Europe child home injuries were both frequent and occurring in a number of typical circumstances, often associated with developmental age changes. While developmental aspects help to understand patterns of child injury, country level housing disparities shed light on inequalities in child health and safety. In fact, in Europe country level disparity in housing and neighborhood conditions forms part of the pathway between between country income inequality (and economic level) and child mortality.

Conclusion: This thesis reveals that nonfatal and fatal child home injuries make an important contribution to the total burden of child injury in Europe. The potential for improvement is high both between and within countries and a number of typical injury circumstances can be targeted. Also, tackling country level housing differentials to reduce material deprivation may assist in both child injury prevention and in the reduction of social inequality in child health and safety.

Providing for more equal access to safe and healthy housing for children is a matter of social justice.

LIST OF PUBLICATIONS

- I. SENGOELGE M, BAUER R, LAFLAMME L. Unintentional child home injury incidence and patterns in six countries in Europe. *International Journal of Injury Control and Safety Promotion*. 2008;**15(3)**:129-139.
- II. SENGOELGE M, HASSELBERG M, LAFLAMME L. Child home injury mortality in Europe: a 16-country analysis. *European Journal of Public Health*. 2010;**21(2)**:166–170.
- III. SENGOELGE M, HASSELBERG M, ORMANDY D, LAFLAMME L. Housing, income inequality and child mortality in Europe: a country-level study. Submitted.
- IV. SENGOELGE M, LAFLAMME L, HASSELBERG M. Country level economic disparity and child mortality related to housing and injuries: a study in 26 European countries. Submitted.

These articles will be referred in the text by their roman numerals I-IV.

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LIST OF ABBREVIATIONS

EU	European Union, 27 countries
EU IDB	European Union Injury Database
EU SILC	European Union Income, Social Inclusion and Living Conditions Database
FAC	Factorial Analysis of Correspondence
HAC	Hierarchical Ascendant Classification
HAC FAC	The combined use of Hierarchical Ascendant Classification with Factorial Analysis of Correspondence
WHO	World Health Organization

1 INTRODUCTION

Injuries are the leading public health threat to children internationally and in Europe, with 115 children dying each day in the European Region and many more being disabled. Children are the most vulnerable members of society and have little power in safeguarding their health, as they have no voice in the decision-making process and thus limited control over their own lives. It is the role of caregivers, neighbourhoods and governments to ensure every child's right to grow up in healthy and safe environments (United Nations, 1989). Yet systematic and broad socioeconomic inequalities exist in child mortality and morbidity rates throughout Europe (Commission on Social Determinants, 2005; European Commission, 2010b; van Doorslaer & Jones, 2004), particularly in child injury (Laflamme et al, 2010; Sethi et al., 2008). As childhood is a crucial life stage, exposure to disadvantages has lasting effects on socioeconomic status and health in adult life (Mielck et al., 2002). Thus, identifying the mechanisms involved in child health inequalities can significantly help to improve not only child health but also the life course. Yet this remains a challenge for public health as it involves targeting proximal and distal pathways.

The European Union was created to be a '*Community*' of Member States, to share resources, capacity and policy frameworks for effective multidisciplinary action. The differences in child injury mortality rates across Europe demonstrate the potential for improvement if interventions were to be implemented across the Region. The financial crisis affecting the eurozone countries shows that although each Member State is unique, they are also bound together and no longer acting alone. Thus, there is a need for coordinated policy action at the European level to address health inequalities in the Region in order to ensure that no matter where a child grows up in Europe, that child will have the same chances for optimal well-being. The European Commission has a role to play by assisting and supporting its Member States to promote evidence-based practice, and to facilitate the exchange of knowledge and experience between countries. Only then can Europe fulfil the goal of making all the countries in Europe among the safest in the world (Sethi et al., 2008).

Tackling health inequalities in Europe must be done as a matter of fairness and a matter of economics, as the European Parliament estimates that losses linked to health inequalities cost around 1.4% of GDP within the European Union - a figure almost as high as the EU's defence spending at 1.6% of GDP (European Defence Agency, 2010). Doing so will require a public health shift from targeting individual risk factors to focusing on altering social conditions that affect health determinants.

In this thesis I explore the scope and circumstances of child injury throughout Europe, and its association with country-level housing conditions and economic disparities. As a mother of two children and a member of the European Child Safety Alliance, I too am committed to making Europe safer for all children.

2 BACKGROUND

Socioeconomic status has been proven to be a fundamental cause of health inequalities (Phelan et al., 2010) and of child injury as well, with abundant research at the individual and area level revealing low socioeconomic status being detrimental to child safety (Laflamme et al., 2010; Sethi et al., 2008). Two broad mechanisms at the individual level have been suggested to explain this, namely differential vulnerability and differential exposure (Wilkinson, 1997; Wilkinson & Pickett 2008). Child injury prevention has mainly focused on vulnerability using education and targeting exposure by reducing risks in and around the home environment. The home is a marker of a child's physical living conditions and inadequate housing contributes to increased child injuries and a range of adverse health outcomes (Braubach et al., 2011; Building Research Establishment, 2008; Krieger & Higgins, 2002; Raymond et al., 2011; Shaw, 2004). Mechanisms also operate at the area and even country level to explain contextual differences in health disparities. These include national differences in social investment (Commission on Social Determinants of Health, 2008; Elstad, 2011) and levels of social cohesion (Kawachi et al., 2002), whereby countries with high economic inequality tend to show higher health disparity (Phelan et al., 2004; Phelan et al., 2010; Willson, 2009). In turn, lower levels of economic inequality and redistributive social health policies, those that provide more equal access to resources, are able to weaken the socioeconomic health gradient (Ross, 2000; Willson, 2009). This is particularly important for Europe as it strives to address health inequality within and between countries in the Region (Commission on Social Determinants of Health, 2005; European Parliament, 2010).

2.1 CHILD INJURY: LEADING CAUSE OF MORTALITY AND SOCIAL INEQUALITY IN HEALTH IN EUROPE

Injuries are a major cause of social inequality in child health in Europe and the leading cause of mortality (Laflamme et al., 2010; Sethi et al., 2008). The leading mechanisms of unintentional child injury in Europe are road traffic injuries, drownings, poisonings, thermal injuries and falls. Where these injuries occur is only known for road traffic as it is coded as such in the International Classification of Diseases data. Currently at the European level it is known how, but not where children are killed. The European Child Injury Prevention Report highlights the high preventability of injury as well as the inequality that exists throughout Europe: the highest unintentional injury mortality rates are almost seven times those in the European countries with the lowest rates and three times higher in low- and middle-income countries compared to high-income countries (Sethi et al., 2008). An estimated 75% of deaths could be avoided if all the countries in the European Region had the same child injury mortality rates as the countries with the lowest rates. Yet accomplishing this is difficult as the aetiology of child injuries is multi-factorial and therefore complex, due to factors at the individual/caregiver level within the home, as well as far-ranging issues such as the wide social and economic differences prevailing within countries across Europe.

2.2 ROLE OF THE HOME ENVIRONMENT

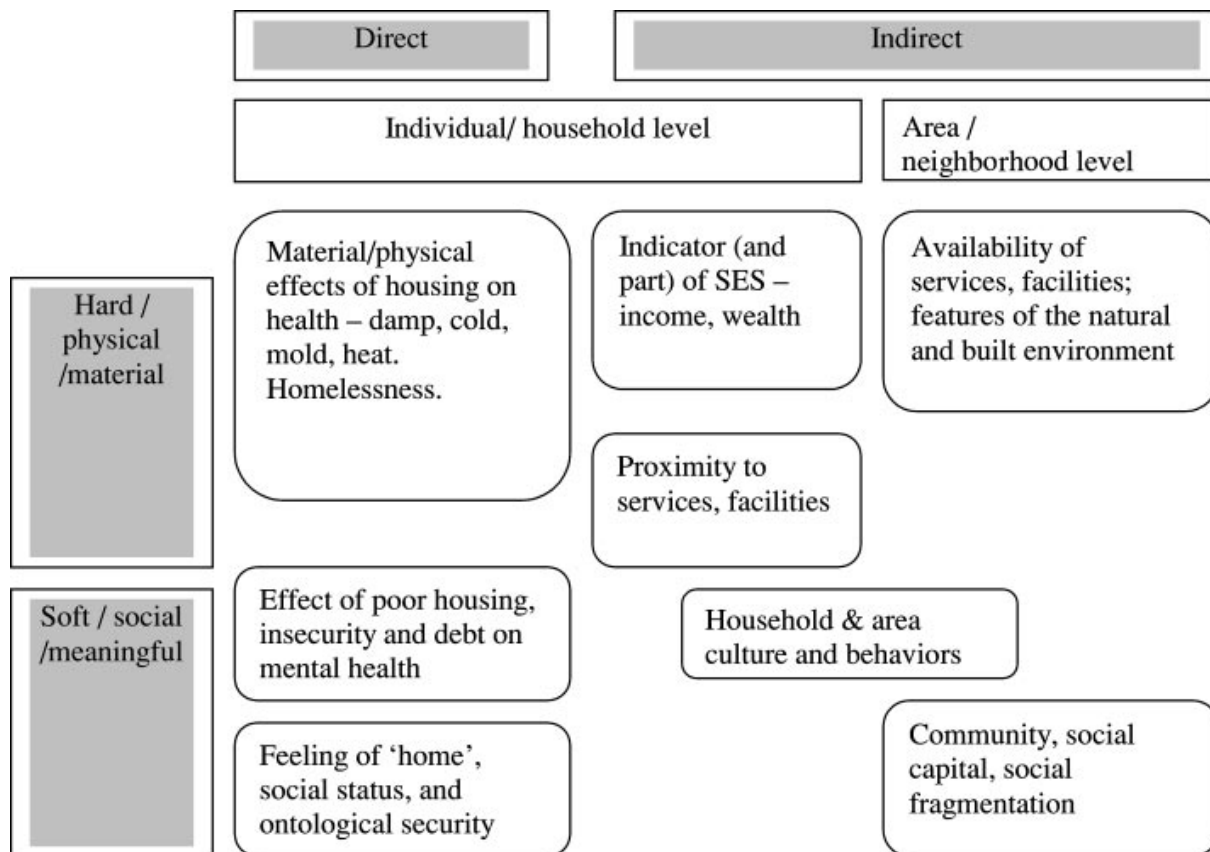
There is growing evidence of the link between the environment and its effect on child health (WHO Regional Office for Europe, 2007), causing more than 100 000 child deaths attributed to exposure to environmental risks in Europe. These risks refer to high levels of road traffic,

indoor and outdoor air pollution, lack of suitable safe spaces for physical activity, poor housing quality, etc. They are unevenly distributed in the Region (WHO, 2010). Quantifying the environmental burden of disease related to housing is taking place at the European level through the selection of a core set of health inequality indicators related to housing, environmental exposure, and home injuries in each country (WHO, 2011) in order to formulate policy to counter the effect of social inequalities on environmental health (Braubach et al. 2011).

The home setting is the first target for injury prevention in young children as it is where they spend the majority of their time. A home represents not only a shelter against the outdoors but also provides children a feeling of security and social status, as well as being formative in the development of habits and values. Yet it is an environment mostly created for adult needs and children are dependent on caregivers for their safety as they explore and interact with potential hazards. The home environment consists of four interrelated dimensions – the physical structure of the house (or dwelling), the home (psychosocial, economic and cultural construction created by the household), the neighbourhood infrastructure (physical conditions of the immediate housing environment) and the community (social environment and the population and services within the neighbourhood) (Braubach et al., 2011). It is these dimensions which alone or in combination impact child health and well-being. For example, children from poor families and deprived areas may live in environments that are less safe, and may lack the socioeconomic resources to avoid risk or adopt protective strategies (Dowswell & Towner, 2002; Laflamme et al., 2010; Phelan et al., 2010). A strong association has been shown between socioeconomic disadvantage and burn injury in both individual and area-based studies in high-income countries (Laflamme et al., 2010). Functional smoke alarms, bath thermostatic mixer valves and stove guards are evidence-based safety products used in the home to reduce the risk of these injuries (Kendrick et al., 2007; Phillips et al., 2011). Poorer families with fewer resources may not have money to purchase or install them (e.g., a plumber is needed for the bathtub thermostatic mixer valve) or have contacts with other families who have this knowledge, or could procure the products on their behalf. They may live in inner-city housing in which the structural design of the home may be a barrier to home safety product usage (Stone et al., 2006).

2.3 EVIDENCE OF THE HOUSING IMPACT ON HEALTH

The #1 recommendation from the Commission on Social Determinants of Health is to improve daily conditions. This is because there is a socioeconomic gradient in exposure to environmental risk factors that is reflected in housing, such that children living in families with lower socioeconomic status have increased exposure to overcrowding, excessive noise, pollution and crime around the home (WHO, 2010). The following model by Shaw (Figure 1) displays the direct and indirect ways in which housing determinants may impact health (Shaw, 2004).



Source: Shaw, 2004

Figure 1. Direct and indirect (hard and soft) ways in which housing can affect health

The joint interaction between child, caregiver and products in the home are examples of direct pathways at the individual level. Child-based variables include gender, temperament and risk taking, while caregiver variables include parents’ beliefs about control over their child’s health, protectiveness, perceptions of the child’s vulnerability to injuries, and perceptions of the importance of safety equipment (Morrongiello et al., 2006a; Morrongiello et al., 2006b). Research shows a significant association between perceived importance of a safety product and possession of such a product, with perceptions of importance not varying by socio-demographic factors (Kendrick, 1994). Another caregiver variable is the nature and scope of child supervision in the home. Parents in fifteen countries in Europe stated that the main difficulty in protecting children from injury was the inability to watch children all the time (Vincenten et al., 2005). As numerous studies have explored these direct factors at the individual/household level, they will not be the focus of this thesis.

Housing design (Lyons et al., 2006b) and maintenance are examples of direct pathways at the household level. For example home repair was found to be significantly associated with injury risk, as homes needing repair were at 3.8 times the risk of injury than homes needing no repair (Dal Santo et al., 2004). More indirect pathways are those related to the neighbourhood, where it has been shown that risks of injury are greater in poor and deprived neighbourhoods, independent of personal characteristics and household circumstances (Haynes et al., 2003). Yet poverty and material deprivation do not fully explain all neighbourhood effects, as neighbourhoods with similar poverty levels have been found to have consistently different injury rates and these differences were also found in comparable

affluent areas (Reading et al., 2005). A multilevel, population-based study found that housing conditions partially mediate the association between community characteristics, such as concentrated poverty and child injuries (Shenassa et al., 2004). Thus, improvements in housing and the quality of the social and physical environment are essential to minimise hazards, compensate vulnerabilities and reduce socioeconomic differences.

2.4 CHILD HOME INJURIES ACROSS EUROPE

A few detailed national examples exist of the burden of child home injuries, such as in the United Kingdom which reports 150 deaths each year of children under the age of 15 years and another one million children visiting an accident and emergency department due to home injuries (DTI, 2005). Estimates suggest that preventing these injuries would result in savings of £9.460 million per year (Roberts et al., 1998), which gives an idea of the potential savings if these injuries were reduced across Europe. Published literature on the costs of home injuries in other countries is scarce. In Motala, Sweden, 35% of all injuries occurred in the home, accounting for the largest share of community costs (29%) with children 0 to 6 years old being a predominant age group (Lindqvist, 2002). The high economic burden of home injuries was also found to have been studied in the USA (Zaloshnja et al., 2005) and in Bavi, Vietnam (Thanh et al., 2003). Preventing child home injuries would not only alleviate unnecessary pain and suffering for children and their families, but also reduce the burden on the health care system. However, the magnitude of fatal or non-fatal injuries in the home versus other locations in Europe is largely unknown. No special registers exist such as for the workplace (European Risk Observatory) or road traffic (EU CARE database) to capture detailed information on the injuries occurring in – and around – the home at the European level. In the EU 15 Member States it was estimated that approximately 10 million home injuries for persons of all ages require medical attention, with around 40 000 resulting in death and one million in hospital admissions (Bonney et al., 2004). Yet these figures remain estimates as the location of the injury is not universally coded in national statistics. Also of interest for effective prevention would be to identify what types of injury mechanisms are involved in child home injuries, and to link this to what products may have caused or be involved in the injury scenario. Finally, there is an abundance of research on the influence of individual and area-level deprivation on child injury leading to differential environmental exposure and vulnerability (Reading et al., 2005; Sellström et al., 2000; Shenassa et al., 2004; Soubhi et al., 2004), but less is known about the role of structural determinants such as material deprivation, absolute or relative, at country level on child injury differentials.

.....
: **“In summary, where you live contributes to determining the risk of accidents in**
: **young children as well as who you are or what you do there”**
: *Source: Reading 2005*
:

2.5 EUROPEAN TRANSNATIONAL POLICY

A child’s right to a safe environment is visible in various policies in Europe, for example the *Ottawa Charter for Health Promotion* (WHO, 1986) the *Istanbul Declaration on Human Settlements* (United Nations Habitat, 1996) and more recently the *European Social Charter*

on the right to adequate housing (Council of Europe, 2008). To support these policies, initiatives such as the Children’s Environment and Health Action Plan for Europe (WHO, 2004) and the Tallinn Charter (WHO, 2008) have been funded at the European level in order to promote cross-country learning and cooperation for recognizing and addressing the link between child health and the environment in the Region. However, no widely accepted, standardised system in Europe exists for caregivers to know whether their home is ‘healthy’ or ‘safe’ for children. Countries rely on national or regional building regulations to regulate hazards in the construction of homes. Yet there are many potential hazards in the home that are not covered by current legislation (Stewart, 2001), and wide variety exists between regulations, within and across countries (Röbbel, 2005).

Three overarching recommendations to tackle health inequalities by the Commission on Social Determinants of Health:

- #1 Improve daily conditions
- #2 Tackle the inequitable distribution of power, money and resources
- #3 Measure and understand the problem of health equity and assess the impact of action

Source: Commission on Social Determinants of Health 2008

Box 1. Recommendations from ‘Closing the gap in a generation’

Member States are motivated ethically and economically to reducing social inequalities and have politically declared their commitment in the European Parliament Resolution on Reducing Health Inequalities in the EU (European Parliament, 2010). The Resolution highlights that health inequalities are rooted in social inequalities in living conditions and the unequal distribution of income and resources, and calls for guidelines to improve the mechanisms to monitor inequalities in health across the EU. As the health and wellbeing of children is a shared value among European countries, a multi-country approach is relevant for the Commission to support and promote, especially with regards to European child safety product legislation and child health policies. Therefore, comparative research at the European level is essential for benchmarking, identifying and understanding inequalities and its determinants within and between countries, and to inform policy makers of the effectiveness of interventions linked to socioeconomic development policies (WHO, 2005). Once we have a better understanding of the proximal and distal mechanisms generating socioeconomic inequalities in child mortality, steps can be taken to systematically address these and in doing so assist in the reduction of child health inequities in Europe.

This thesis is a contribution in that direction.

3 AIM AND RESEARCH QUESTIONS

This thesis aims to increase knowledge about the characteristics of child home injuries and the manner in which housing interplays in the association between economic disparities at country-level and child mortality, specifically injuries, within a European context.

To achieve this aim the following four research questions will be addressed:

Non-fatal unintentional child injuries in the home setting (0 to 18 years)

- What is the incidence and patterns of unintentional child home injuries requiring hospital treatment? (Article I)

Fatal child injuries in the home setting (0 to 14 years)

- What is the proportion and incidence of fatal child injuries in the home compared to other locations? (Article II)

Housing conditions and economic disparity related to child mortality (1 to 14 years)

- At country level how do housing inequality and income inequality relate to one another and how do they relate to child mortality? (Article III)
- Do country-level housing conditions contribute to explain the association between economic differences and child mortality? (Article IV)

4 METHODS

To respond to the four research questions described above the thesis is structured around four sub studies, each leading to one article. The articles answer four research questions, as illustrated in Figure 2. Firstly, circumstances of nonfatal injuries in the home environment are examined, followed by the scope of fatal home injuries, and then an ecological analysis of child injury mortality rates and the association with housing conditions and economic disparity.

Each of the articles reflects a European multi-country context. Article I provides general attributes of nonfatal child injuries, concentrating on the incidence and patterns of unintentional child injuries in the home. Article II introduces country economic level of development and focuses on child cause-specific injury mortality, in the home versus other locations. Articles III and IV expand upon the macro-level indicators by analysing income inequality and housing conditions, and their relationship to age- and cause-specific child mortality.

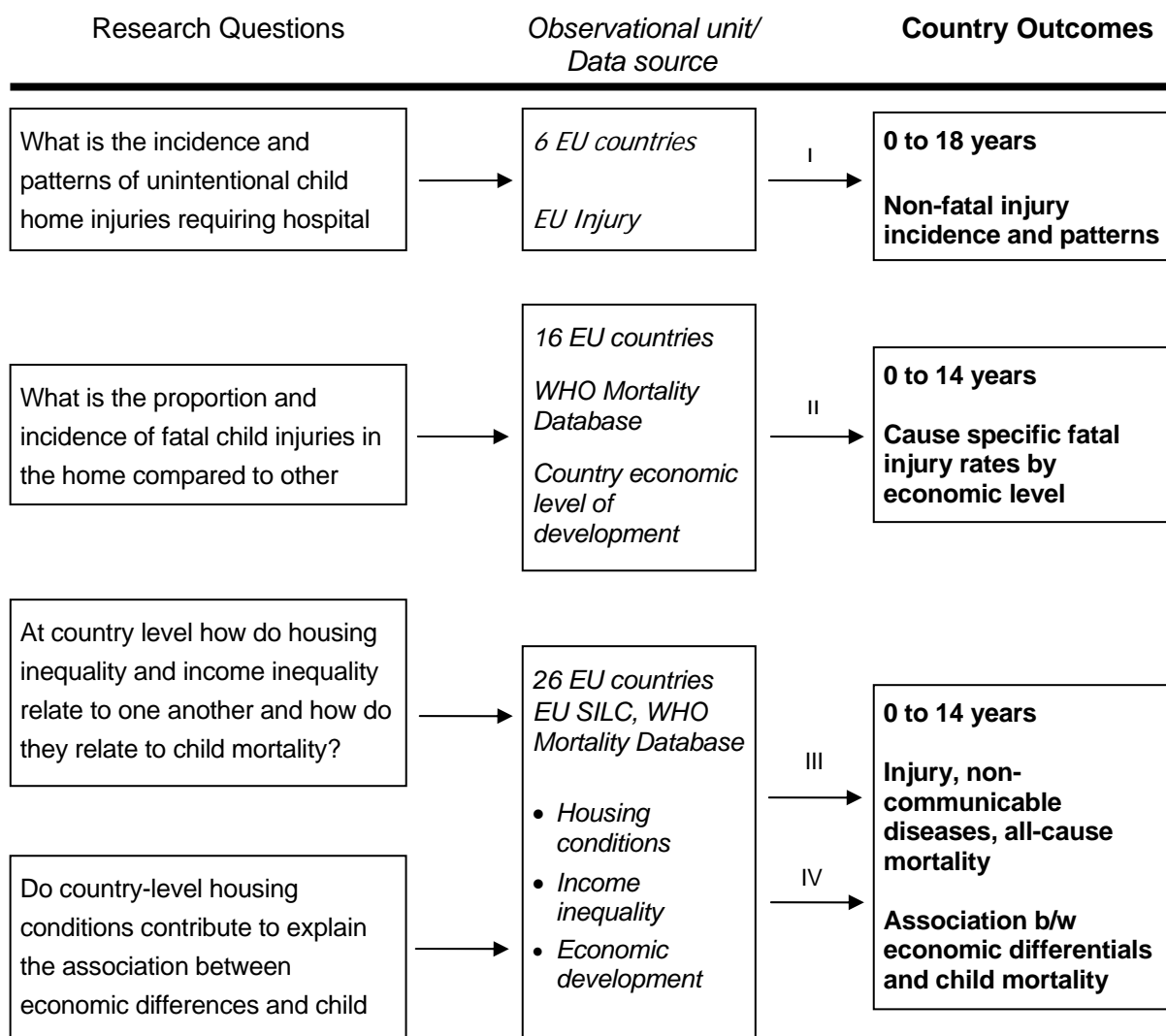


Figure 2. Overview of the research framework

4.1 SETTING

The four articles analyse data from Europe, focusing on the European Union (EU) which is an economic and political partnership between 27 democratic European countries, comprising a population of nearly half a billion (<http://europa.eu/>). The EU was established in 1993 by the Maastricht Treaty and started with 12 Member States, and now has 27 Members and accession countries planning to join in the future. The EU has 23 official languages and covers more than 4 million km² with each Member State varying in size and reflecting cultural diversity. The 27 EU Member States are comprised of 19 high income countries, Austria, Belgium, Cyprus, the Czech Republic, Denmark, Finland, France, Germany, Greece, Ireland, Italy, Luxembourg, Slovenia, Spain, the Netherlands, Portugal, Sweden and the United Kingdom; and eight upper middle income countries, Bulgaria, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Romania, and Slovakia. The main European bodies are the European Parliament (representing the people of Europe); the Council of the European Union (representing national governments); and the European Commission (representing the common EU interest). The Directorate General for 'Health and Consumers' at the European Commission is responsible for the health of its citizens throughout the EU.



Source: www.lib.utexas.edu/maps/europe/europe_pol_2004.jpg

Figure 3. Map of Europe

4.2 DATA SOURCES

Because a cross-country comparison was relevant for this thesis in order to identify cross national investments in equity and safety, the material is based on three European sources (see Figure 2): the EU Injury Database (Article I), the World Health Organization Mortality Database (Articles II-IV), and the European Union Income, Social Inclusion and Living Conditions Database (Articles III, IV).

4.2.1 Data Source 1 – The EU Injury Database (EU IDB), register-based

The EU injury database (EU IDB, <https://webgate.ec.europa.eu/sanco/heidi/index.php/IDB>) was established and funded by the European Commission Directorate General for Health and Consumer Protection in 1999 to host data collected by the Member States on injury hospitalisation and emergency visits for unintentional injuries in the home and leisure environments. The IDB was formerly the European Home and Leisure Accidents Surveillance System (EHLASS). Work and road traffic data were excluded from the IDB as these data are collected by other databases in the EU. The EU IDB is comprised of unintentional injury data collected in accident and emergency departments from a random or exhaustive sample of hospitals in Member States. Work and road traffic data are excluded from the IDB as these data are collected by other databases in the EU. The EU IDB provides information on external causes and injury circumstances, specifically: age and sex of the victim, injury place of occurrence, activity during injury, sports practiced during injury, type of injury, part of body injured, mechanism of injury, treatment and follow-up of injury, a free text description of the event and products having a role in the injury—a product refers to any object in the environment, ranging from a floor surface to furniture, toys, etc. that causes or is involved in the injury (European Commission, 2002). Yearly approximately 500 000 cases are collected from 58 hospitals throughout the EU (Bauer, 2005). Currently the database includes all injury data from 13 countries.

The EU IDB calculates crude incidence rates based on the aggregated catchment population of the hospitals of the participating countries. Two main methods are used to define a “catchment population” and calculate an estimate of national incidence from the IDB sample. One is a population based method (calculation of local or regional incidence rates through identifying and quantifying a catchment area for a given hospital) and the second a patient registry based method (using the sample ratio, percentage of cases in the sample versus all cases, to extrapolate any selection of IDB data to the total number of equivalent cases in all hospitals of the country) (Injury Database (IDB) Population Task Force, 2007). Austria, the Netherlands and Portugal use the patient registry based method and Denmark, France, and Sweden use the population-based method.

Table 1. EU IDB variables and definition of place of occurrence

EU IDB variables:	*Place of occurrence defined as:
Country code	Kitchen
Age	Living room/bedroom
Sex	Bathroom/washroom
Time of injury	Stairs indoors
Mechanism of injury	Garden
Activity at time of injury	Private driveway
Sports at time of injury	Playground in residential area
Body part injured	Residence indoors, other
Type of injury	Residence outdoors
Treatment and follow-up	Residential area, other
Product involved in the accident	
Product causing the injury	
Free text description of injury	
Place of occurrence*	

4.2.2 Data Source 2 – The World Health Organization (WHO) Mortality Database, register-based

The WHO Mortality Database is available online (WHOSIS, <http://www.who.int/whosis/mort/download/en/index.html>) to calculate average annual mortality rates based on the International Classification of Disease. The data are national statistics that are sent to the WHO comprising deaths registered in national vital registration systems with the underlying cause of death coded by the relevant national authority. Population data are also supplied for the population covered by the death registration system. Also provided is an estimate of the proportion of all deaths that are registered in the population covered by the vital registration system for a country, referred to as completeness of death recording for the latest available data year. As the vital registration data may be 100% complete for the population covered but not include full coverage of deaths in the country, the overall level of coverage for the latest available year for each country is also listed. The coverage is calculated by dividing the total deaths reported for a country-year from the vital registration system by the total estimated deaths for the national population that year. To protect the privacy of the data no personal information is coded. Furthermore, no socioeconomic data, place of occurrence, or injury characteristics are available in this global database, as all countries worldwide do not consistently code these data. There is an average two-year delay for access to the data due to the standardisation work needed at WHO Headquarters in Geneva, Switzerland so that data are comparable on a global level.

4.2.3 Data Source 3 – European Union Statistics on Income, Social Inclusion and Living Conditions (EU SILC), multidimensional survey

The European Union Statistics on Income and Living Conditions (EU-SILC, http://epp.eurostat.ec.europa.eu/portal/page/portal/microdata/eu_silc) was launched in 2003 as a multi-purpose instrument to provide comparative statistics on income distribution and social exclusion at European level. EU-SILC is the main source for the compilation of comparable indicators on social cohesion used for policy monitoring at EU level (European Commission, 2006). It collects multidimensional micro-data on income, poverty, social exclusion, and living conditions from information on housing condition, labour, education and health information each year. The reference population of EU SILC is all private

households and its members residing in the country at the time of data collection. Persons living in collective households and in institutions are generally excluded. The data are based on nationally representative probability samples and data collection is flexible, with interviews being conducted in the majority of the countries using paper assisted computer interviews, computer assisted personal interviews and computer assisted telephone interviews. Seven countries extract most or part of the administrative information from national registers (Denmark, The Netherlands, Slovenia, Finland, Sweden, Iceland and Norway). The EU-SILC is based on the idea of a common “framework” that defines the harmonised lists of target primary (annual) and secondary (every four years or less frequently) variables to be transmitted to Eurostat. This framework aims to maximise comparability of the information using common procedures, concepts, and classifications. Although specific items for children are not included in the EU-SILC variables, the items on social necessities are relevant for children.

4.3 DATA TREATMENT

The data treatment necessary to answer the research question for each article is presented below.

What is the incidence and patterns of unintentional child home injuries requiring hospital treatment? (Article I)

Article I focuses on the first research question, identifying the incidence and typical circumstances of nonfatal, unintentional child injuries occurring in and around the home that require hospital treatment. First, a Factorial Analysis of Correspondence (FAC) was performed on the coded values of nonfatal, unintentional child injuries resulting in hospitalizations. Next, the variables were analysed simultaneously employing a cluster method called the Hierarchical Ascendant Classification (HAC) (Benzécri, 1985; Greenacre, 1984), most suitable for the treatment of categorical data. The HAC was performed on the first 10 factors of the FAC, which entailed using the coordinates of the injuries analysed on the first 10 factorial axes (cumulating 53.4% of the cumulated variance). This identified patterns which described the circumstances of the injuries.

What is the proportion and incidence of fatal child injuries in the home compared to other locations? (Article II)

Article II addresses the second research question by determining the proportion and incidence of fatal child injuries in the home compared to other locations, and introduces an economic variable into the analysis. Firstly, WHO mortality data were extracted for the 53 countries in Europe and from these 16 countries were selected into the study because they provided injury data to WHO for the years 2002 to 2004, and used the ICD-10 classification system. These countries were then grouped based on their economic development as classified by the World Bank, resulting in countries of upper middle income and high income. In order to compare home injuries to injuries in other locations, the fourth digit code of the ICD-10 was used to determine the location of the injury. Injuries occurring in the home environment were extracted by selecting the fourth digit code ‘0’ of the codes X40-Y86; the injuries taking place in locations other than the home, referred to as ‘other injuries’, were extracted by selecting the fourth digit code ‘1-8’. Transportation-related injuries were extracted from the

codes V01-V99 ('motor-vehicle traffic accidents' and 'other transport accidents'). The injuries for which the location was unspecified were identified by the fourth digit code '9'. Finally, a ranking was made of the top five causes of fatal home injuries in children 0 to 14 years in all countries aggregated. The unintentional cause 'all other accidents including late effects' was excluded due to lack of specificity.

The sub study is similar for Articles III and IV in that both used the ecological design to address the role of housing conditions in 26 European countries, of which 19 high- and seven middle-high income. Yet thereafter the research questions examined go in different directions.

At country level how do housing inequality and income inequality relate to one another and how do they relate to child mortality? (Article III)

In article III an index of country level housing conditions was created using variables from the 26 countries participating in the EU SILC database that depict housing, neighbourhood and household economic conditions. These included variables reflecting housing general characteristics such as dwelling type, rental/owner status, house size/type as well as housing problems, for example leaking roof, pollution, crime, and ability to keep the home warm. Descriptors of the household economic conditions were also taken into consideration. This resulted in 40 variables being retained that could give a broad picture of the potential sources of differential housing conditions between countries. Next frequencies of selected variables were examined that differentiated between the countries under study, followed by the exclusion of redundant variables by looking at correlations. This overall selection process resulted in eleven country-level variables discriminating the countries under study. Then, an exploratory factor analysis using the principal component method was performed and factor scores estimated. Article III explored the association between country level housing conditions and income inequality. Income inequality was measured using the 2006 Eurostat 80:20 income quintile share ratio of cumulative income held by the richest 20% and poorest 20% of the population. Each country was studied separately as well as all countries aggregated using correlation coefficients (SPSS Version 18.0). The outcome variables were age-specific (1-4, 5-9, 10-14, 1-14 years) injury and noncommunicable diseases mortality rates which were derived from the WHO Mortality Database.

Do country-level housing conditions contribute to explain the association between economic differences and child mortality? (Article IV)

Article IV used the same index of housing conditions at country level as article III and introduced two country-level economic differentials, income inequality and economic level of development. The level of country development was derived from the World Bank categorisation based on gross national income per capita, defined as high-income (19 countries) and middle-high income (7 countries). The outcome variable was the mortality rate of children 1 to 14 years of age for all-cause mortality and unintentional injury mortality (road traffic and all other unintentional injuries), as these injuries are the leading cause of death in children in Europe (Sethi et al., 2008). Regression analysis, univariate and multivariate with a p-value of 0.05 significance was performed using SPSS Version 18.0 on the 26 countries aggregated, to examine the contribution of housing conditions in the association between economic level/income disparity and child mortality rates.

5 RESULTS

5.1 HOW FREQUENT ARE UNINTENTIONAL NONFATAL HOME INJURIES AND HOW DO THEY HAPPEN?

5.1.1 Injury incidence

Article I reported that the crude annual incidence of emergency department-attended child home injuries based on the average of the six Member States under study was 44.9 (95% CI 29.1-60.7) per 1 000 inhabitants. The incidence peaked at one to two years of age in all countries and then declined as the age group increased (see Figure 4). This corresponded to a high of 118.0 (95% CI 70.6-165.4) and low of 22.5 (95% CI 11.9-29.7) per 1 000 inhabitants.

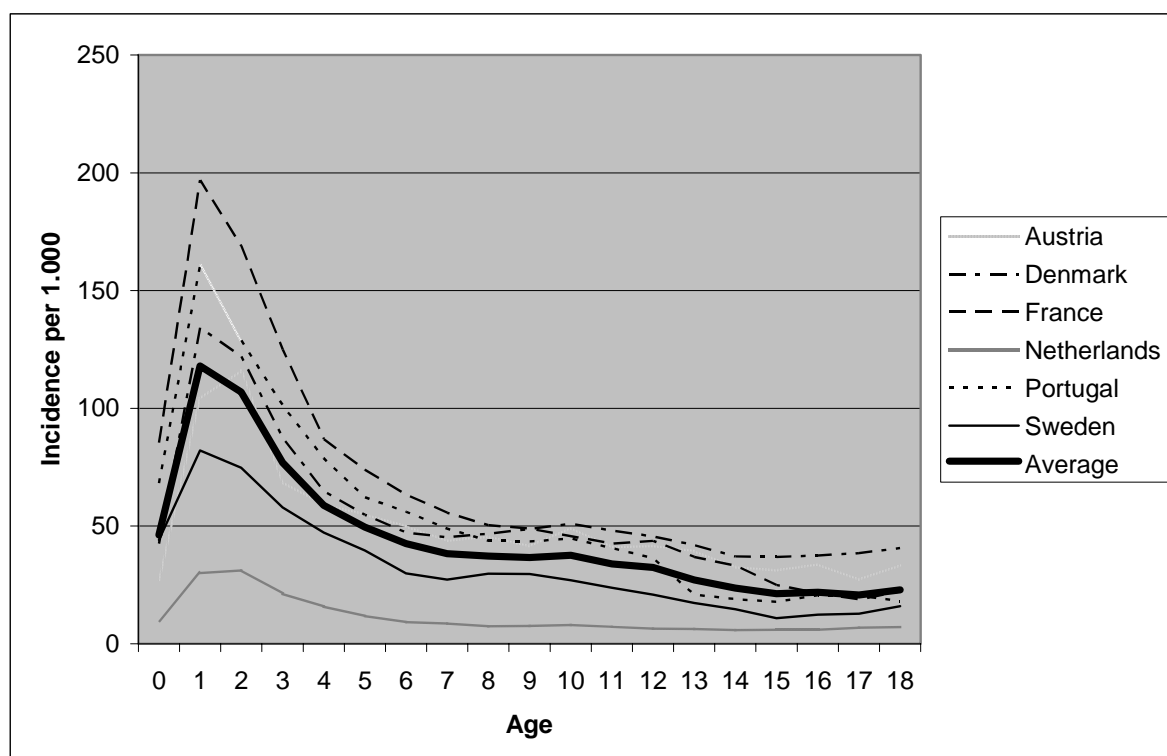


Figure 4. Estimate of child home injury incidence by age per country

5.1.2 Six injury clusters resulting from the HAC

By means of a cluster technique, six consistent injury clusters were highlighted. Figure 5 portrays the categories of variables that contributed significantly ($p < 0.05$) to the formation of each cluster. Five clusters concerned circumstances of specific injury characteristics and one cluster was nonspecific. Cluster 1 represented injuries typically resulting in open wound head injuries; Cluster 2 concerned hospitalization for bruises, contusions, and abrasions; Cluster 3 concerned falls on stairs indoors; Cluster 4 represented injuries resulting in fractures and sprains of the upper extremities; Cluster 5 concerned crush/cut/piercing injuries to the fingers; and Cluster 6 were a mixture of miscellaneous injuries.

**Hospitalisation for
bruises/contusions/abrasions**

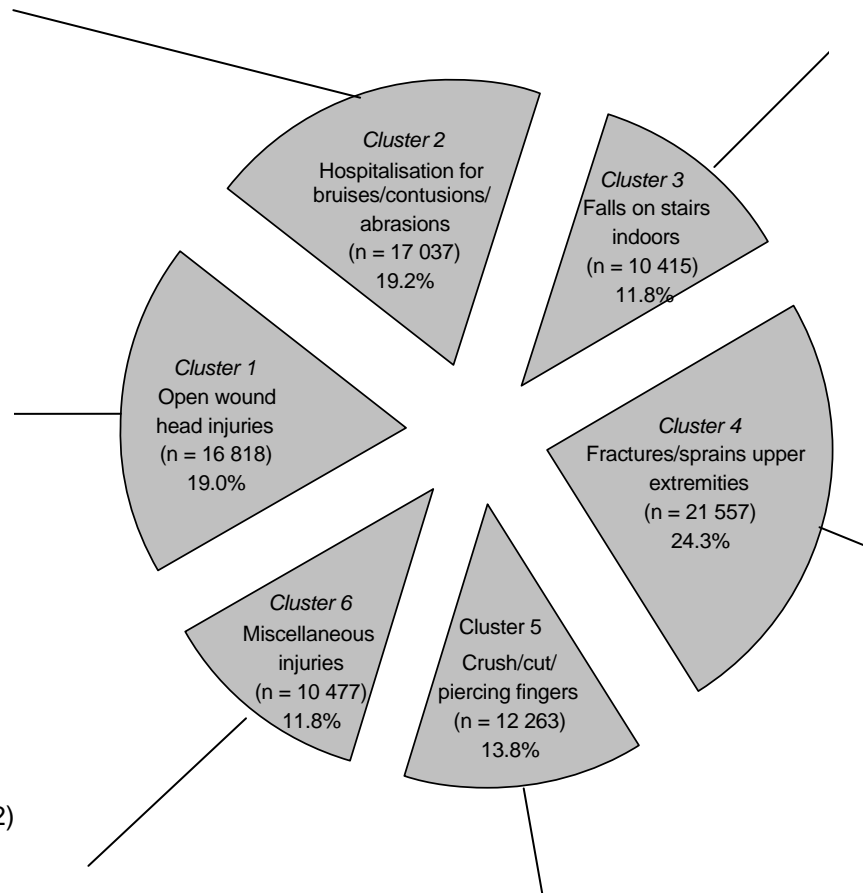
- Bruises, contusion, abrasion (68.2)
- Examined, sent home without treatment (66.4)
- 0 to 4 years (60)
- Female (44.6)
- Residence indoors, other (40.9)
- Skull and brain (37.2)

Open wound head injuries

- Open wound (82.9)
- Head, neck, throat (79.6)
- 0 to 4 years (64.9)
- Male (63.1)
- Sent home after treatment (48.2)
- Living room/bedroom (39.5)

Miscellaneous

- Other mechanism incl. other (un)specified and unspecified (87.2)
- 0 to 4 years (64.8)
- Type of injury other specified and unspecified (47.4)
- Type of injury other specified and unspecified (46.9)
- Female (46.2)
- Head, neck, throat (30.1)



Falls on stairs indoors

- Falls from different levels, including stairs (93.2)
- 0 to 4 years (63.8)
- Bruise/contusions/abrasions (55.8)
- Skull and brain (49.2)
- Female (47.5)
- Sent home after treatment (46.4)

Fractures/sprains upper extremities

- Fractures/sprains (64.9)
- Upper limbs, excl. fingers (50.4)
- Female (48.6)
- Sent home after treatment (45.5)
- Treated and referred for further treatment by general practitioner or outpatient (42.9)
- Lower limbs thorax abdomen (39)

Crush/cut/piercing fingers

- Crush/cut/piercing (86)
- Finger (62.1)
- Male (57.4)
- Open wound (56.3)
- Sent home after treatment (50.8)
- Treated and referred for further treatment by general practitioner or outpatient (34.2)

5.2 HOW FREQUENT ARE CHILDHOOD FATAL HOME INJURIES COMPARED TO INJURIES IN OTHER LOCATION?

Article II considered 16 countries with different economic levels. The analysis showed that the majority of the upper middle income countries under study tended to have higher fatal home injury incidence rates for children 0 to 14 years compared to the high income countries, with Romania ranking highest in each age group (Table 2). This is especially true for the under one age group in which Romania has a 62 time higher rate of fatal home injury compared to the countries with the lowest rate (Iceland, Luxembourg) (Table 2). In contrast, Poland had very low rates compared to the other upper middle income economy countries, for the 0 to 14 years overall and in each separate age group. Table 2 also shows the wide range in fatal home incidence rates even within the high income economies; for all children combined, the rates ranged from 0,75 in Spain to 2,46 in the Czech Republic.

5.2.1 Ranking of fatal home injuries

The top five causes of fatal home injuries in children 0 to 14 years in all countries aggregated were: drowning/submersion, fire/flames, poisoning, falls, homicide and injury purposely inflicted by other persons. These deaths accounted for almost 90% of all home injury deaths.

5.2.2 Location of fatal child injuries

Sixty-percent of injuries to children under one year occurred in the home environment, compared to 11% in transport. Fatal home injuries were highest in children under five, both in numbers and proportions of the total, and then sharply decreased. This is in contrast to the fatal transport injuries which increased as age increased. The highest proportion of unspecified injuries (26%) was in children under one year of age and then decreased as age increased.

Table 2. Fatal home injury incidence rate, average 2002-2004, 16 European countries by income* and age

Country	0-1 year	1-4 years	5-9 years	10-14 years	0-14 years
Upper middle income economies					
Croatia	10,90	2,07	0,66	0,89	1,64
Hungary	12,05	3,48	0,75	1,96	2,51
Lithuania	39,57	11,21	4,04	3,60	7,13
Poland	7,64	1,45	0,61	1,27	1,43
Romania	62,02	15,85	5,67	7,20	11,94
High income economies					
Austria	2,58	1,04	0,52	0,62	0,80
Czech Republic	8,20	2,50	1,78	2,12	2,46
France	4,49	2,83	0,70	0,85	1,58
Germany	3,50	2,21	0,57	0,48	1,11
Iceland	0,00	1,98	3,05	0,00	1,52
Luxembourg	0,00	1,48	2,30	1,20	1,58
Malta	8,46	3,93	0,00	0,00	1,36
Netherlands	3,82	2,28	0,71	0,86	1,40
Norway	2,96	0,99	0,54	1,72	1,21
Spain	1,71	1,35	0,48	0,35	0,75
United Kingdom	4,82	1,89	0,44	0,70	1,16

*Source: http://www.ivsc.org/members/wb_members.html

5.3 HOUSING RELATED TO INCOME INEQUALITY AND CHILD MORTALITY AT COUNTRY LEVEL

Article III analysed nine measures of living conditions that highly differentiated European households at country level. By means of an exploratory factor analysis these measures clustered into three dimensions, labelled respectively housing, neighbourhood and household economic strain. All three strains tended to be worse in the more unequal countries (Latvia, Lithuania, Greece, Portugal) as compared to more equal countries (Sweden, Denmark, Finland, Netherlands). The Pearson correlation coefficients were used to show that income inequality significantly correlated with housing strain ($r=0.62$, $p=0.001$) and neighbourhood strain ($r=0.42$, $p=0.009$) but not with household economic strain ($r=0.34$, $p=0.087$).

5.3.1 Association of income and housing inequality to child mortality at country level

At country level, injury and noncommunicable disease mortality rates for children 1-14 years were positively correlated with both income and housing inequality, but not for neighbourhood strain. Also, higher dispersion was seen in injury mortality compared to noncommunicable disease rates as the income or the housing inequality gap increased among the European countries.

5.3.2 Age-specific cause mortality correlation with income and housing inequality for all countries aggregated

When the 26 countries were aggregated, Figure 6 illustrates that child injury mortality rates correlated more strongly with housing strain than with income inequality, with negligible age specific differences. By contrast, and with the exception of children aged 10 to 14 years, noncommunicable diseases correlated strongly with housing conditions, but with age specific differences in relation to income inequality. It is noteworthy that noncommunicable disease rates among young children (1-4 years) and for all ages (1 to 14 years) strongly correlated with both the housing strain and income inequality, possibly driven by a higher concentration of mortality in the younger age group. Both noncommunicable disease and injury rates showed little correlation with neighbourhood strain (data not shown), with the highest correlation reached for children 1 to 4 years followed by all injury ages aggregated.

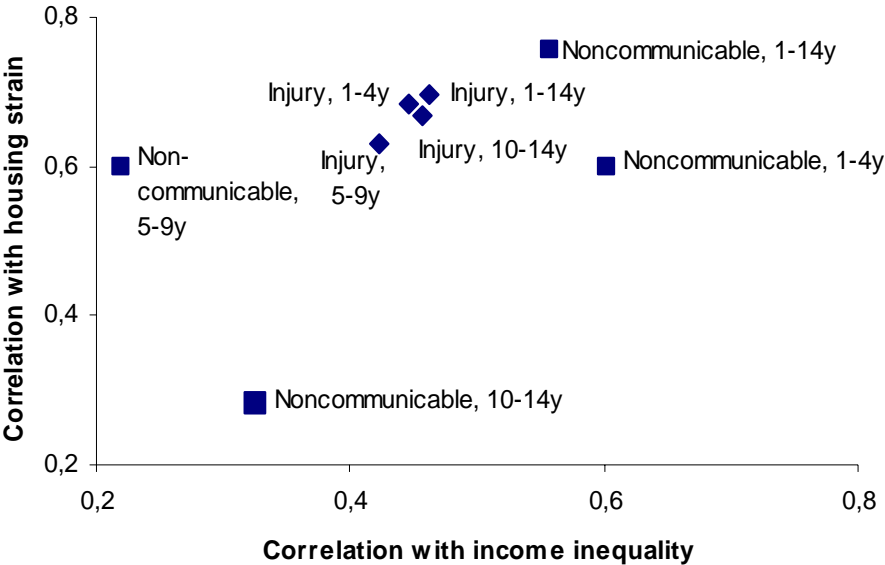


Figure 6. Income inequality and housing strain

5.3.3 Additional results of interest

As Latvia consistently had the highest mortality rates, one may argue that as an outlier it may have skewed the results of article III. To investigate this further the analysis was redone regarding the association between country level income inequality and each of the three strains. Table 3 shows the change in correlation coefficients including and excluding Latvia. For all three strains the association was weakened when Latvia was excluded, with the greatest reduction in the correlation coefficient existing for income inequality and neighbourhood strain.

Table 3. Association between country level income inequality and housing conditions in 26 versus 25 European countries

	26 European countries including Latvia	25 European countries excluding Latvia
Income inequality and housing strain	r = 0.62	r = 0.51
Income inequality and neighbourhood strain	r = 0.34	r = 0.09
Income inequality and household economic strain	r = 0.42	r = 0.34

5.4 CONTRIBUTION OF HOUSING TO ECONOMIC DISPARITY AND CHILD MORTALITY AT COUNTRY LEVEL

When examining the contribution of housing in the association between country economic level and child mortality, article IV found that adjusting for housing and neighbourhood strain increased the strength of the association for all cause and all injury mortality causes, but resulted in only a minimal difference when stratifying unintentional injury causes (road traffic and other unintentional injury) (Table 4). These results are in contrast to those found when examining housing and the association between country income inequality and child mortality. In this situation adjusting for housing strain increased the strength of the association between income inequality and all-cause mortality (R^2 0.47, $p < .01$) for all-injury (R^2 0.45, $p < .01$) (Table 5). In contrast, adjustment for neighbourhood disparity did not alter the strength of the association in any mortality cause (Table 5). For both economic level and income inequality, the interaction between economic disparity and housing and neighbourhood strains contributed to explain the association between economic disparity and each of the mortality causes (Table 4 and Table 5).

Table 4. Association between economic level and child mortality in 26 European countries, 2006

	Economic level							
	All-cause		All-injury		Road traffic injury		Other unintentional injury	
	R ²	p value	R ²	p value	R ²	p value	R ²	p value
Crude	0.56	<.01	0.43	<.01	0.27	0.01	0.45	<.01
Adjusted for housing strain	0.64	<.01	0.48	<.01	0.43	<.01	0.46	<.01
Adjusted for neighborhood strain	0.61	<.01	0.49	<.01	0.30	0.02	0.52	<.01
Interaction housing/ neighborhood strain	0.71	<.01	0.58	<.01	0.45	0.02	0.63	<.01

Table 5. Association between income inequality and child mortality in 26 European countries, 2006

	Income inequality							
	All-cause		All-injury		Road traffic injury		Other unintentional injury	
	R ²	p value	R ²	p value	R ²	p value	R ²	p value
Crude	0.40	0.01	0.44	<.01	0.36	<.01	0.39	<.01
Adjusted for housing strain	0.47	<.01	0.45	<.01	0.44	<.01	0.39	<.01
Adjusted for neighborhood strain	0.40	<.01	0.44	<.01	0.36	0.01	0.40	<.01
Interaction housing/ neighborhood strain	0.52	0.01	0.51	0.01	0.50	0.01	0.43	0.04

6 DISCUSSION

The majority of data concerning child injuries at the European level is based on the consequences of the injury, such as death rates, disability adjusted life years or length of hospital stay (Sethi et al., 2006). There is limited information in the published literature on the topic of child home injuries within a European perspective (KfV, 2009). Yet public health professionals have a long history of involvement in housing interventions related to the prevention of infectious diseases. More recently they are involved in the prevention of chronic illnesses such as asthma (Krieger & Higgins, 2002) and in interventions aiming to change parent safety practices in the home (Kendrick et al., 2007). But how else and to what extent does the housing environment represent harm to children's safety?

6.1 MAIN FINDINGS

6.1.1 Characteristics of child home injuries

What was already known on this topic:

- In the EU 15 Member States it was estimated that approximately 10 million home injuries for persons of all ages require medical attention and one million result in hospital admissions.
- No European Union estimates exist of the number of nonfatal child injuries in the home.

What Article I adds:

- The crude annual incidence of emergency department-attended child home injuries based on the average of the six Member States was 44.9 (95% CI 29.1-60.7) per 1,000 inhabitants.
- In Austria, Denmark, France, the Netherlands, Portugal and Sweden the incidence of nonfatal child home injuries peaked at one to two years of age and declined as the age group increased.
- Six distinct injury patterns were found for nonfatal child home injuries. They were different in size and often closely linked to the age and development of the child, but were not gender specific.

Box 2. Article I key points

In Article I the average incidence based on data from six high income countries in the Western part of the EU was used to extrapolate to the population of the EU 27 Member States as a whole. This resulted in an estimated 22 million children, 0-18 years of age, who suffer a home injury each year serious enough to visit the emergency department. This incidence is within a comparable range to the two child home injury non-fatal incidence estimates from the United States of America, 56 per 1,000 (Phelan et al., 2005), 57 per 1 000 (Runyan & Casteel, 2004) and one from the Lazio region of Italy, 35 per 1 000 (Chini et al., 2006). In addition the study identified six specific injury patterns. Not surprisingly the characteristics and circumstances of these patterns related to the age/developmental level of the child but not to their gender. Four patterns were more typical of the young (cluster 1, 2, 3, and 6) and involved open wound head injuries and falls, especially on indoor stairs as children master walking and climbing. Similar

findings exist in other studies showing that falls are the major cause of unintentional injury in the home for 0 to 4 year olds, with injury to the head decreasing as age increases (Ashby & Corbo, 2000; Government Consumer Safety Research, 1999; Thélot, 2005). The other two patterns occurred in older children (cluster 4 and 5). They typically involved fractures and sprains of the upper extremities on play equipment in the garden, which has been found at the national level (Schalamon et al., 2011) and crush/cut/piercing of the fingers in older children coming in contact with products designed for adult use (knives, glass products). In addition, for five out of the six patterns the injury outcome was not severe as the majority of cases were not hospitalised, with the exception of cluster 2: hospital admissions for bruises, contusions, abrasions. These findings are in line with previously reported emergency department results on nonfatal child injuries at national level, in which minor injuries, defined as bruises, minor head injuries, lacerations and sprains accounted for 80% of all injuries and products involved were bunk beds, staircases, playground equipment (O'Carroll et al., 2009) and non-tempered glass tables (Kimia et al., 2009).

Article I represented a first attempt at the European Community level to use cross-country data for a European level assessment. These results provide evidence that nonfatal child home injuries are a considerable public health problem in Europe which requires attention. They also seem to occur with a given specificity (considering that patterns can be identified). Regarding how prevention can be achieved, the point has been made many times that child home injuries – as is the case for injuries in general (Christoffel & Gallagher, 1999; Laflamme et al., 1999) have a multifaceted aetiology due to the simultaneous interaction of the environment with the caregiver and child behaviour (Simpson et al., 2009). This having been said, it is unclear what the relative importance of each such type of factors is in child injury causation. Yet, the home environment itself can be regarded as a potentially effective target for prevention as it is a modifiable determinant of health and safety (Shaw, 2004).

6.1.2 Fatal injuries in 16 countries – home versus transport

What was already known on this topic:

- If all of the countries in the European Region had the same child mortality rates as those with the lowest rates, an estimated 75% of deaths would be avoided.
- The leading mechanisms of unintentional child injury in Europe are road traffic injuries, drownings, poisonings, thermal injuries and falls.

What Article II adds:

- Sixty-percent of injuries to children under one year occurred in the home environment, compared to 11% in transport.
- The top five injury mortality causes in the home were drowning/submersion, thermal injuries, poisoning, falls, and homicide, all of which account for almost 90% of deaths among children 0 to 14 years of age.
- The majority of the upper middle income countries tended to have higher fatal home injury incidence rates compared to the high income countries.

Box 3. Article II key points

Article II studied fatal child injuries in 16 upper middle and high income countries in Europe by injury place of occurrence. This analysis gives another picture of the injury risk distribution in

children, as the home environment appears less safe for the youngest and most vulnerable children. Very young children of five years of age and under were almost six times more likely to die in the home environment compared to traffic. A potential reason for this is that young children are most fragile physically and may spend more time in the home environment compared to older children. The ranking of child home injuries in this study was similar to the one completed in Europe of unintentional injuries to children for all injury locations (Sethi et al., 2008), except that in the home environment drowning was first instead of road traffic injuries, and thermal injuries and poisonings were reversed. Furthermore, intentional injuries were included in the analysis that resulted in homicide ranking fifth. These results clearly point to the need for more efforts to be undertaken at the European level to try and reach all stakeholders about the potential dangers in the home environment concerning very young children. A quantitative survey of parents of children aged five years or under performed in 14 EU Member States found that lack of awareness or knowledge about the causes of accidents was the second most cited response as to why it is difficult for caregivers to protect their children from accidental injury (Vincenten et al., 2005). Also, two-thirds of these parents would like to see more help from the government to prevent childhood injuries. Other research shows that parents were aware of risks but did not have the resources to address the problems and socioeconomic status was an important predictor of observed home hazards (Kronenfeld et al., 1992). In addition to caregiver awareness and risk perception, evidence-based interventions exist to prevent these injuries and parenting interventions have been shown to be effective in reducing unintentional child injury (Kendrick et al., 2007).

As inequalities in child injury mortality in the European Region have been shown to exist over decades for all types of injuries (Sethi et al., 2008)(UNICEF, 2001), article II sought to look into country differences in child mortality in the home environment using a measure of economic development. The study found that fatal child home injuries vary in magnitude across Europe and, to some extent, according to the economic level of the country. Overall, upper middle income countries were at higher risk for fatal home injuries compared to high income economies. This injury inequality was also found when comparing trends for all injury deaths across Europe (Armour-Marshall et al., 2011). The study by Armour-Marshall et al. found that child injury deaths have decreased in all regions, but the gap between western Europe and the north-western Commonwealth of Independent States has grown from 4.0 times greater child injury fatalities in 1991-93 to 5.7 times greater in 2006-08. A review of empirical studies within countries found that low socioeconomic status at both the individual and area level was harmful to children, for injuries as a whole and injury causes separately (Laflamme et al., 2010). The higher risk profile in Romania in particular is difficult to ascertain; it is a country of upper middle economic level and has an income inequality equal to that of the EU 27 Member States. Thus, it differs from its neighbours who have significantly higher income inequality (calculated 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). Only one published study was found of nonfatal child injuries from a large children's hospital in one major city of Romania. The annual average nonfatal all injury incidence was 157 per 100 000 children 0 to 18 years based on this one hospital (Oprescu et al., 2008). For comparative purposes the EU incidence is 9 per 100 000 for children 1 to 19 years, unintentional child injury only (Sethi et al., 2008). Possible explanations include Romania being one of the poorest countries in the EU with a high level of corruption in the country, so that fewer resources are available for creating safe environments for all children (Armour-Marshall et al., 2011).

6.1.3 Role of country level housing and economic disparity on child health and safety

What is already known on this topic:

- Injuries are the number one cause of death in children in Europe, have a strong socioeconomic gradient and are highly preventable.
- High income inequality and low economic level negatively affects child health and safety.
- Inadequate housing is associated with poorer child health and safety.
- Housing is a modifiable social determinant of health, acting through a range of direct and indirect pathways.
- Housing operates both at individual and contextual levels.

What studies III and IV add:

- Income inequality significantly correlates with two dimensions of housing, namely housing strain and household economic strain.
- Child injury mortality rates correlate more strongly with country level housing strain than income inequality and age specific differences are negligible.
- Housing conditions significantly contribute to explain the association between both country economic level and country income inequality and child mortality (all causes or all injury causes).
- Adjusting for housing and neighborhood strain respectively strengthens the association between country economic level and child mortality for most mortality causes. For country level income inequality, only adjustment for housing strain strengthens the association.
- Housing conditions may buffer the negative impact of country economic differentials on child safety and health.

Box 4. Article III and IV key points

Articles III and IV investigate the role of housing in the association between economic disparity and child mortality outcomes, specifically injuries, within 26 European countries of upper middle and high income. Why study injuries in Europe which is relatively well off compared to other regions of the world? Because the European Region shows large differences in injury mortality when one examines injuries in relation to country economic disparity (Sethi et al., 2006). Why examine economic disparity in relation to child health? Because children are more at risk of poverty than the general population and child poverty is distributed unequally in Europe. In the 27 Member States of the European Union child poverty is three-fold higher in Eastern European countries compared to the Nordic countries (European Commission, 2008). Also, economic disparity is a marker of material deprivation that has adverse effects on child health, in Europe and other settings (Collison et al., 2007; Dorling et al., 2007; Hales et al., 1999; Kaplan et al., 1996; Kondo, Singh & Kogan, 2011; Mielck et al., 2002; Pickett & Pearl, 2001; Pickett & Wilkinson, 2007; Ram, 2005; Wilkinson, 1997; Wilkinson & Pickett, 2008). Finally, why explore housing beyond it being the injury place of occurrence? Because housing

is a marker of how children live and the housing is regarded as a mechanism through which deprivation affects health in the population (Braubach et al., 2011; Jacobs et al., 2010; Ormandy, 2009; Shaw, 2004). Last but not least, housing is a modifiable determinant of health (Gibson et al., 2011; Thomson et al., 2001).

Our findings from Article III show that in all 26 European countries considered, the country level housing, neighbourhood and household economic strains worsened with increasing levels of income inequality. Both child injury and noncommunicable disease mortality rates correlated more strongly with housing strain than with income inequality, but with very small age specific differences for injury compared to age specific differences for noncommunicable diseases. Article IV found that both housing and neighbourhood conditions were of importance in countries with different economic levels, while housing alone played a role in countries with higher income inequality. Yet the interaction of housing and neighbourhood had a pronounced increased effect on most child mortality causes.

These studies form part of the body of research investigating more closely the potential macro-determinants of the unequal distribution of health (Pickett & Wilkinson, 2007; Wilkinson, 1997; Wilkinson & Pickett, 2008). They show support for the notion that housing operates at country level by significantly contributing to the relationship between both country economic level and country income inequality and child mortality. Thus, housing conditions may act as a proxy for material conditions (Shaw, 2004) and are not only an important determinant of child health, but also a likely mechanism of influence on economic disparity and child health. It is essential to intervene as soon as possible as longitudinal studies revealed that multiple housing deprivation led to a greater risk of disability or poor health in later life (Marsh et al., 1999), independently of the effects of socioeconomic deprivation in child or adulthood (Dedman et al., 2001). Countries that have systematically addressed the social determinants of child injury also have the lowest injury mortality rates in the Region (Sethi et al., 2008). For example, Sweden's commitment to regulations and legislation mandating safer living environments combined with a sense of social responsibility has resulted in decades of low child injury mortality rates (Bergman & Rivara, 1991). Furthermore, there is evidence showing that housing improvements addressing structural deficiencies (installed working smoke alarms, four-sided isolation pool fencing and preset hot water temperature) may assist in reducing unintentional deaths and injuries (DiGuseppi et al., 2010). Measures of potential lives saved must be combined with the costs of inadequate housing to society (in the United Kingdom the cost is estimated at over £600 million a year) (Roys et al., 2010), as well as the financial savings to the health sector from housing investment (Audit Commission, 2009).

6.2 STRENGTHS AND LIMITATIONS

Country level comparisons are important for research and policy purposes, in order to examine what determinants beyond the individual and area level affect a particular health outcome, in this case child safety. This necessitates access to comparative material/data sources and the use of an ecological, cross-sectional design. Such an approach has certain limitations.

6.2.1 Ecological and cross sectional study limitations

Limitations to ecologic studies include the “ecological fallacy,” that one cannot necessarily infer the same relationship from the group level to the individual level, as well as a lack of

information on the cross-classification of individual-level characteristics within groups (Morgenstern, 1998; Susser, 1994a; Susser, 1994b). With this study design one can only draw inferences and one must rely on further testing of specific hypotheses about causation. Yet even though an ecological design has its drawbacks there are situations when this design is not only adequate but also essential, for instance in order to study country level determinants. In studies III and IV we examined country level mechanisms that may impact what is happening at the household level. Furthermore, it is not likely that measurement error is present in the classification of countries according to economic level or income disparity, as these measures are robust and have been systematically captured for years. Nonetheless, with this design it was not possible to control for the many confounding factors and complicated interactions that may be present when performing this type of study.

A limitation related to the cross-sectional design is the difficulty in differentiating cause and effect from simple association, as the association is examined at one time point and gives no indication of the temporal sequence between exposure and the health outcome (Bland, 2001). To address this issue the exposure data on housing was captured in 2006 and the child morbidity and mortality outcome data used were from 2006 to 2008.

Another challenge to this design is that confounding factors may be unequally distributed in the study sample, which may lead to bias and subsequent misinterpretation. This may be an issue for instance in Study I as the sampling frame in each country is based on a sample of hospitals that may not be representative of the entire child population at country level (Bauer, 2005; Keall, 2011b). Presently, validation studies on EU IDB data do not exist. Yet a strength of this dataset is that recall of the injury circumstances is captured immediately post-injury via interviews in the emergency department, therefore minimizing recall bias.

Further limitations were found in the data sources used in this thesis that may have impacted the validity of the findings presented in Articles I to IV.

6.2.2 Data sources' strengths and limitations

EU IDB - Variations in coding practices and hospital treated injuries in the EU

The EU IDB is a selection of cases that come into contact with the hospital accident and emergency department. As a result certain data limitations and biases must be taken into account when comparing data sets; specifically differences in sampling, extrapolation methods and health care consumption and hospitalisation practices across countries (accessibility, specialisation of the hospitals causing under- or overrepresentation of certain injuries, etc.) (Bauer, 2005). Also, although uncoded data are relatively few in the EU IDB database some "unspecific" codes are used quite systematically for certain types of injuries. A consequence of this is the lack of precision relative to these injury events. Another methodological issue is that there is no standardised procedure when calculating the incidence to define and calculate the catchment populations across countries contributing to the IDB. As a result country differences in sampling and extrapolation methods may exist, which in turn potentially impacts the validity of the injury incidence calculated in each country. In order to be able to make national comparisons, these biases and comparability between IDB data sets must be assessed and improved (Lyons et al., 2006a). Due to this weakness an aggregated incidence had to be shown in article I, which limited the ability to compare rates between countries. Cross-country comparisons would be useful for benchmarking purposes.

WHO Mortality Database – Quality of injury data and place of occurrence

Although the International Classification of Diseases is intended to provide a standard way of recording underlying cause of death, comparisons across countries should be undertaken with caution due to certain limitations. These include incorrect or systematic biases in diagnosis, incorrect or incomplete death certificates, misinterpretation of rules for selection of the underlying cause, and variations in the use of coding categories for unknown and ill-defined causes. WHO provides two quality measures of national mortality data, namely estimates of data completeness and data coverage. The proportion of all deaths registered in the population covered by the vital registration system for a country is referred to as completeness of death recording. The coverage is calculated by dividing the total deaths reported for a country-year from the vital registration system by the total estimated deaths for the national population that year. One limitation is that these estimates of coverage and completeness are calculated based on all ages combined, thus it is uncertain how similar they are for children only. For this thesis the coverage was 98% or better for all countries under study except for Iceland (91%) and the estimated completeness was 100% for all countries. Thus, the data from these countries can be considered reliable for deriving national injury fatalities for all ages (Bhalla et al., 2011). Yet because the number of child fatal deaths in Europe is relatively low compared to global rates (Peden et al., 2008) there was insufficient statistical power to stratify the data by sex. Abundant research exists at area level showing that boys have increased rates of injury mortality and morbidity for injury all cause and injury specific (Sethi et al., 2008). Therefore, this was not a focus of this thesis.

Regarding the quality of the WHO data related specifically to injury, a study was undertaken to investigate the quality of the fourth digit code, place of occurrence of fatal injuries within the European region. The analysis was based on the completeness, coverage and percentage of unspecified place of injury occurrence. The study found that few countries in Europe have high quality data on place of occurrence of injuries and the remaining countries have medium to low quality data (Suárez-García et al., 2009). For article II this has implications on the accuracy of the ranking of fatal child injuries in the home, as it is unknown what proportion of the unspecified place of injury may have occurred in the home. This misclassification of the outcome data potentially means that the data in article II underestimate the extent of home-related child deaths. It is imperative that national and European efforts are made to commit resources for training in coding of injury place of occurrence in order to accurately follow trends within and across countries.

EU SILC - Quality of household survey on living conditions for cross-country comparisons

The EU SILC data are collected annually by the majority of the EU countries via surveys, registers or a combination of both. There is concern that this difference in sources may account for measured differences in findings, especially as Nordic countries tend to use registers and also have lower levels of income inequality and relative poverty (European Commission, 2007a). Yet it is recognised by Eurostat that there is a need for systematic assessment of EU SILC comparability with external sources. Furthermore, the data on housing conditions used to conceptualise the notion of the home environment indexes rely on self-reporting as no public health officials were employed to inspect the homes on site based on a standardised assessment form. Thus self-reporting bias may exist. The household response rate was high (ranged from 61% to 95% with the 26 country average at 80%) and there is no reason to believe that

substantial differences would arise between countries regarding the self-reported data on the housing variables selected. These variables were used to discriminate between countries regarding sources of differences. Yet, it was not possible to 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 underrepresented as they are hard to reach. This may play a more important role in upper middle income countries where the percentage of vulnerable groups may be higher.

Furthermore, no child-specific items were included in the EU-SILC 2006 data, therefore it may be that material deprivation measures specific to children's life conditions that may be different from their parents were not captured. Nonetheless, the EU SILC remains the key source for measures of income, housing, labour information and social exclusion due to its adherence to data quality guidelines and procedures aimed at maximising comparability at the EU level, as documented by Eurostat (European Commission, 2007a).

6.3 IMPLICATIONS FOR PRACTICE AND POLICY

As stated above the numbers of deaths and injuries reported in this thesis have limitations that may tend to result in an underestimate of the true magnitude of child home injuries – both fatal and non fatal – in Europe. Yet although there are gaps in the existing data used to examine this issue, the findings support the notion that these injuries make an important contribution to the total burden of child injury in Europe, and may even pose a bigger problem than injuries in the road environment.

6.3.1 Environmental home modifications

All children have a right to safe and healthy housing, which is a modifiable determinant (Gibson et al., 2011; Thomson et al., 2001). Articles I and II highlight the need to implement environmental modifications to make the home environment safer regarding child injury prevention. This is challenging as the injury clusters also indicate (not surprisingly) that child home injuries are multifactorial and the circumstances are related to normal, everyday activities such as playing and walking (Simpson et al., 2009; Simpson & Nicholls, 2011). Nonetheless, in line with the lessons learned in injury prevention research and practice (Christoffel & Gallagher, 1999; Laflamme et al., 1999), focus must be placed on the structural quality of the home and modifications of potential hazards, such as falls associated with stairs. Cost benefit models performed in England show that improving homes would provide health benefits and save millions of pounds per year through reduced injury rates and treatment costs (Roys et al., 2010). Also, as stressed by many others, it is necessary to promote the use of evidence-based safety products for the prevention of fatal and nonfatal child home injuries that are in tune with the age and development of the child. In doing so, development and safety should go hand in hand. Such products include child-friendly surfaces for reducing the severity of head injuries, stair guards to prevent the falls on stairs, impact absorbing surfacing for outdoor play, appropriate anchoring of furniture (Cho et al., 2009; Wolf et al., 2011), and bath thermostatic mixing valves for the prevention of bath water scalds. UK research showed that installing bath mixing valves was not only effective (Kendrick et al., 2011) but also cost-effective (Phillips et al., 2011). To facilitate uptake of these products, interventions should use focused messages, target simple and

one-time changes, and provide free equipment and fitting in addition to education (Ingram et al., 2011). Injury prevention professionals have an important role to play here.

6.3.2 European surveillance of housing conditions

In the United Kingdom there exists a Housing Health and Safety Rating System to investigate the relationship between housing hazards and health impacts, specific to injuries and health conditions (Office of the Deputy Prime Minister, 2003). A hazard category and average hazard score are calculated for each hazard, as well as the identification of vulnerable groups based on the likelihood of occurrence of an injury within one year. Such a Housing Database is lacking in other countries. In 2004 the World Health Organization housing and health program in Europe performed a European housing and health survey in eight cities in Europe, titled WHO LARES (Large Analysis and Review of European Housing and Health Status), confirmed that housing scores are needed to determine the priority areas for protecting public health (Bonney et al., 2004). These data are needed at country level to assess housing quality in a systematic and standardised manner, in order to accurately estimate the environmental burden of disease and injury related to housing throughout Europe (Keall et al., 2011b). There is also a need for public health professionals to advocate for passive, evidence-based prevention measures to be incorporated into building standards, such as window guards, smoke alarm detectors and bath thermostatic mixing valves.

6.3.3 European home safety action plan

Research has made clear that the relationship between child health disparities and economic disparities is not inevitable, but policy amenable (UNICEF, 2007). As the health and wellbeing of children is a shared value among European countries (European Commission, 2007b), a multi-country approach is relevant and will require cross-sectoral commitment. The EU has a mandate to complement national action on health by assisting Member States who may not be able to act effectively alone, and to provide cooperative action at the European level. A home safety action plan in Europe is needed to commit to a collaborative, multi-sectoral effort to address the issue of home safety throughout Europe. Such an initiative exists for road safety at the global level via the Global Plan for the Decade of Action for Road Safety 2011-2020 (United Nations, 2011). And for many years now this takes place at the European level with the European Commission funding a Road Safety Action Plan (2001-2010) and now the Road Safety Programme 2011-2020 to assist Member States in cutting road deaths in Europe in half (European Commission, 2010a). 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., 2011b). Therefore the same, if not more, resources being allocated for road safety should also be set aside for home safety. This follows that the Commission would see the value of also supporting a European Home Safety Programme 2012-2021; see Box 5 for recommendations of what such a programme may entail.

Recommendations for a European Home Safety Programme:

1. Creation of a European Home Safety Observatory funded by the European Commission to coordinate home safety research on surveillance, prevention and evaluation, including cost effectiveness studies of large scale housing interventions at country level.
2. Supporting innovation in the design of child home safety products via European Commission Call for Tenders directed towards designers, architects and engineers.
3. Providing a harmonised identification and assessment of housing conditions at the European level for use in an EU-wide representative survey of housing conditions.
4. Establishing a WHO Europe Task Force to examine how to improve the quality and completeness of injury data, specifically place of occurrence and proportion of unspecified injury coding.
5. Developing research priorities to improve understanding of the magnitude, impact and cost of fatal and nonfatal child home injuries, including use of longitudinal data at country level to investigate the effect of housing throughout childhood.

Box 6. European Home Safety Action Plan

7 CONCLUSION

This thesis reveals that nonfatal and fatal child home injuries make an important contribution to the total burden of child injury in Europe. The potential for improvement is high both between and within countries. The results support the notion that tackling country level housing differentials may assist in both child injury prevention and in the reduction of social inequality in child health and safety. As a whole the studies contribute to the information platform needed to address this essential public health problem at the European level. Providing for more equal access to safe and healthy housing for children is a matter of social justice.

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