ARTICLE IN PRESS

Health & Place ∎ (∎∎∎∎) ∎∎∎–∎∎∎

Contents lists available at ScienceDirect

Health & Place

journal homepage: www.elsevier.com/locate/healthplace

Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project)

Carme Borrell [a,b,c,*], Marc Marí-Dell'Olmo [c,a,b], Gemma Serral [a], Miguel Martínez-Beneito [d], Mercè Gotsens [c,a], other MEDEA members[1]

[a] Agència de Salut Pública de Barcelona, Spain
[b] Universitat Pompeu Fabra, Spain
[c] CIBER Epidemiología y Salud Pública (CIBERESP), Spain
[d] Centro Superior de Investigación en Salud Pública, Valencia, Spain

ARTICLE INFO

Article history:
Received 21 May 2009
Received in revised form
4 March 2010
Accepted 9 March 2010

Keywords:
Mortality
Geographical inequalities
Urban areas
Small areas

ABSTRACT

The objectives of this study are to identify inequalities in mortality among census tracts of 11 Spanish cities in the period 1996–2003 and to analyse the relationship between these geographical inequalities and socioeconomic deprivation. It is a cross-sectional ecological study where the units of analysis are census tracts. We obtained an index of socioeconomic deprivation and estimated SMR by each census tract using hierarchical Bayesian models which take into account the spatial structure. In the majority of the cities geographical patterns in total mortality were found in both sexes, which were similar to those for the index of socioeconomic deprivation. Among men, four specific causes of death (lung cancer, ischemic heart diseases, respiratory diseases and cirrhosis) were positively associated with deprivation in the majority of cities. Among women the specific causes diabetes and cirrhosis were positively associated, while lung cancer was negatively associated with deprivation. The excess of mortality related with deprivation was 59,445 deaths among men and 23,292 among women. These results highlight the importance of intra-urban inequalities in health.

1. Introduction

Within European countries, there are many examples of systematic inequalities in health between social classes, the most deprived population groups having worse health and higher mortality (Whitehead and Dahlgren, 2006; Mackenbach et al., 2008; Marmot et al., 2008). Moreover, most of these inequalities have increased over time (Shaw et al., 1999; Mackenbach et al., 2003; Borrell et al., 2008).

In the last two decades, the number of studies treating geographical area as a health determinant has increased, probably due to re-awakened interest in social and environmental determinants of health (Krieger, 2008; Jerrett et al., 2005), availability of data at the small area level and development of methodology and software to analyse the spatial distribution of health based on Geographical Information Systems (Krieger, 2003; Rushton, 2003). The analysis of inequalities in health in geographical areas is important for at least three reasons. First, there are contextual factors at the area level that explain health outcomes, such as the physical environment, urban sprawl, the labour market, leisure facilities, educational facilities, health care and social institutions, just to name a few (Macintyre et al., 2002; Macintyre and Ellaway, 2003). Second, the identification of geographical areas with worse health and socioeconomic

* Corresponding author at: Agència de Salut Pública de Barcelona, Plaça Lesseps 1, 08023 Barcelona, Spain. Tel.: +34 93 2384545; fax: +34 93 2173197.
E-mail address: cborrell@aspb.cat (C. Borrell).

[1] Elena Aldasoro[e], Maria Antònia Barceló[f,c], Joan Benach[g,c,h], Montse Calvo[e], Koldo Cambra[e], Antonio Daponte[i,c], Felicitas Domínguez-Berjon[j], Santiago Esnaola[e], Ana Gandarillas[j], Berta Ibáñez[k,c], José Miguel Martínez[g,c], Carmen Martos[l], Imanol Montoya[m], Carles Muntaner[n], Andreu Nolasco[o], M. Isabel Pasarín[a,b,c], Javier García-Pérez[p,c], Rosa Puigpinós[a,c], Rebeca Ramis[p,c], Maica Rodríguez-Sanz[a,c], Rosa Ruiz[e], Marc Saez[f,c], Pablo Sánchez-Villegas[i], Margarita Taracido[q], Oscar Zurriaga[d,r]. [[a]Agència de Salut Pública de Barcelona, Spain; [b]Universitat Pompeu Fabra, Spain; [c]CIBER Epidemiología y Salud Pública (CIBERESP), Spain; [e]Departamento de Sanidad, Gobierno Vasco; [f]Research Group on Statistics, Applied Economics and Health (GRECS), University of Girona, Spain; [g]Occupational Health Research Center, Department of Experimental and Health Sciences, Universitat Pompeu Fabra, Barcelona (Spain); [h]Health Inequalities Research Group. Employment Conditions Knowledge Network (Emconet); [i]Observatorio de Salud y Medio Ambiente de Andalucía (OSMAN), Escuela Andaluza de Salud Pública, Consejería de Salud, Junta de Andalucía, Granada, Spain; [j]Subdirección de Promoción de la Salud y Prevención. Consejería de Sanidad. Comunidad de Madrid, Spain; [k]Fundación Vasca de Innovación e Investigación Sanitarias (BIOEF), Spain; [l]Instituto Aragonés de Ciencias de la Salud; [m]Unidad de Investigación de Atención Primaria de Bizkaia. Osakidetza-Servicio Vasco de Salud, Spain; [n]Center for Addictions and Mental Health, University of Toronto, Canada; [o]Unidad de Investigación en Análisis de la Mortalidad y Estadísticas Sanitarias, Universidad de Alicante, Alicante, Spain; [p]Department of Environmental Epidemiology and Cancer, National Centre for Epidemiology, Carlos III Institute of Health, Madrid, Spain; [q]Universidad de Santiago de Compostela; [r]Área de Epidemiología. Dirección General de Salud Pública. Valencia (Spain)]

1353-8292/$ - see front matter © 2010 Elsevier Ltd. All rights reserved.
doi:10.1016/j.healthplace.2010.03.002

conditions facilitates the implementation of interventions and policies to tackle inequalities in health (Kjellstrom, 2008). And third, monitoring health inequalities can be more feasible and routinely done using ecological data (Borrell and Pasarin, 2004).

An understanding of the processes occurring in urban areas is a key factor to understand the economic, cultural, political and health transformations in a given country since today the majority of the world's population lives in urban areas (Kjellstrom, 2008; UN-Habitat, 2006; Galea and Vlahov, 2005). In addition, socioeconomic inequalities in health tend to be larger in urban areas with deprived and poor populations being concentrated in marginalized neighbourhoods and urban slums located at the centre or peripheral areas of these cities (Diez Roux, 2007; van Lenthe et al., 2005; Borrell and Pasarin, 2004).

Small area analysis permits gaining a deeper understanding of geographic patterns and clusters of inequalities in health and has proved to be essential in uncovering local-level inequalities often masked by health estimates from large areas such as states, regions or cities. Moreover, the rise of Bayesian methodologies and other powerful new small-area techniques have provided better statistical tools to carry out these analyses (Lawson et al., 2000; Clayton and Bernardinelli, 1992). For all these reasons, the description of health inequalities in small areas of cities has importance for researchers, policy makers and the general population.

Intra-urban inequalities in mortality have not been analysed a great deal in Europe (van Lenthe et al., 2005; Stafford et al., 2004) and have only been studied in a small number of cities in Spain (Dominguez-Berjon et al., 2005; Ocana-Riola et al., 2008; Nolasco et al., 2009). Moreover, when studying inequalities within cities, the areas usually analysed are neighbourhoods, mainly because of the difficulties which an analysis of smaller areas entails. Therefore, the objectives of this study are to identify inequalities in total mortality, and in cause-specific mortality, among census tracts of eleven large Spanish cities, as well as to analyse the relationship between these geographical inequalities and socioeconomic deprivation at the turn of the 21st century.

2. Methods

2.1. Design

This study was carried out in the framework of a project known as MEDEA (*Socioeconomic and environmental inequalities in mortality in small areas of Spanish cities*—http://www.proyectomedea.org/) conducted jointly by 10 Spanish research groups. This study uses a cross-sectional ecological design whose goal is to analyse mortality inequalities at the small area level in Spanish cities. The units of analysis were the census tracts of the 11 largest cities included in the study according to the 2001 Population and Households Census. These cities included 20.5% of the Spanish population in 2001 and are located in a variety of regions (Autonomous Communities) of Spain, from the wealthiest to the poorest: Catalunya (city of Barcelona), Comunidad de Madrid (Madrid), Euskadi (Bilbao), Aragón (Zaragoza), Comunitat Valenciana (Alicante, Castellón and Valencia), Galicia (Vigo), Andalucía (Córdoba, Málaga, Sevilla).

2.2. Study population and information sources

The study population consisted of people residing in the cities during the period 1996–2003. Mortality data were obtained through the mortality registries of the Autonomous Communities or from the mortality registry of the city in the case of Barcelona.

Expected number of deaths in each census tract were calculated taking as reference mortality rates by sex, age (5 year age-specific mortality rates) and cause of death for Spain, year 2001, which were provided by the National Institute of Statistics (Instituto Nacional de Estadística). In order to elaborate an index of socioeconomic deprivation the source of data was the 2001 Population and Household Census. The Population and Household Census was also used to obtain information on the number of inhabitants stratified by sex, age (in five-year groups) and census tract.

2.3. Variables

Number of deaths by five-year age groups, sex, census tract of residence, and the underlying cause of death were extracted from mortality registries. The census tract was obtained through the postal address of the deceased provided by either the Death Certificate or by the Local Census. Due to technical problems in geocoding place of residence, for some deaths could not be geographically referenced, the proportions varying from 0.13% in Bilbao to 14.28% in Vigo. Except for Vigo, these percentages were always lower than 7%. Underlying causes of death were coded using the International Classification of Diseases: 9th revision (ICD-9) for deaths occurred between 1996 and 1998, and 10th revision (ICD-10) for those occurred between 1999 and 2003.

The present study has analysed all-cause mortality, and mortality for 10 of the leading specific causes of death in Spain (lung, breast and prostate cancer, diabetes, mental diseases, Alzheimer, ischemic heart diseases, cerebrovascular diseases, respiratory diseases and cirrhosis). These causes accounted for 43.9% of all deaths among men and 68.6% among women in Spain for the year 2001.

2.4. Socioeconomic deprivation index

Material deprivation refers to the lack of access to conditions related with health such as a healthy job, housing, home facilities or a safe environment. Many indicators have been proposed to measure deprivation (Dominguez-Berjon et al., 2001). In this study, a deprivation index was calculated for each census tract using the methodology proposed by Dominguez-Berjon et al. (2008) (principal component analysis), based on the socioeconomic indicators available for each census tract. Five simple indicators were included in this index (year 2001): (a) Unemployment: percentage of people aged 16 years or over actively seeking a job in relation to the total economically active population; (b) Low educational level: percentage of people aged 16 years and over with less than 5 years of schooling or with 5 years of schooling or more who did not complete basic compulsory education, in relation to the total population aged 16 years and over; (c) Low educational level in young people (16–29 years); (d) Manual workers: percentage of people aged 16 years or over, employed, who are manual workers in relation to the total employed population aged 16 years or over; and (e) Temporary workers: percentage of people aged 16 years or over, employed in temporary jobs, in relation to the total employed population aged 16 years or over. The index is normalized with a mean 0 and standard deviation of 1. The index of deprivation accounted for more than 75% of the variability of the socioeconomic indicators included.

2.5. Data analysis

The observed deaths (O_i) for each census tract ($i=1,\ldots,n$) follow a Poisson distribution with mean $\mu_i=E_i\theta_i$, where E_i were

Please cite this article as: Borrell, C., et al., Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project). Health & Place (2010), doi:10.1016/j.healthplace.2010.03.002

the expected cases for each census tract obtained by indirect standardization, and θ_i was the relative risk for each specific area. The maximum likelihood estimate (MLE) of θ_i was the standardized mortality ratio (SMR) for the ith census tract: $\widehat{\theta}_i = O_i/E_i$ (the ratio between observed and expected deaths) with estimated variance proportional to O_i/E_i^2, and consequently, may present high variability in areas with small populations. Therefore, in order to control this variability in estimating the risk we used Bayesian models, and more specifically the model proposed by Besag et al., 1991) (BYM) which takes into account two types of random effects: spatial (S_i) and heterogeneous (H_i). Prior distributions are assigned to the random effects, and hyper prior distributions to the parameters of the prior distributions. In our case, for the spatial effect, we chose a conditional autoregressive normal distribution (CARN) whose precision matrix (the inverse of the variance–covariance matrix) is proportional to the neighbourhood matrix between census tracts, considering as neighbouring areas any that share part of their frontiers, and a normal distribution with mean 0 and variance σ_h^2 for the heterogeneous effect. Following the suggestion by Gelman et al., (Gelman, 2006; Best et al., 2005; Barcelo et al., 2008), a uniform distribution U (0,5) is assigned to the standard deviation of the random effects. The model assumes that the logarithm of the mean of the observed mortality has the following form:

Model A: $\log(\mu_i)=\log(E_i)+\alpha+S_i+H_i$; where α is the constant term.

As an extension to model A we add the deprivation index (X_i)

Model B: $\log(\mu_i)=\log(E_i)+\alpha+\beta_1 X_i+S_i+H_i$; where $e^{\beta_1}$is the relative risk associated with the deprivation index.

As the scale of the deprivation index is adimensional, the interpretation of β_1 is somewhat cumbersome and useless if it is not accompanied by the scale of variation of the deprivation index. Therefore, to illustrate the impact of deprivation on mortality we present, for every cause of death and city, the relative risk of the census tract with percentile 95 of the deprivation index (highest deprivation) vs. the census tract with percentile 5 (lowest deprivation). This indicator can be considered as a trimmed measure of the inequalities arising from deprivation for every city and cause, as it compares both ends of the scale and has been trimmed (to 5 and 95 percentiles) to make it more robust. From now on, we will call this indicator the Relative Risk (RR) without any other additional comment.

The estimations of RR were assessed through the mean of the posterior distribution and its 95% Credibility Interval (95%CI). This distribution was obtained using Monte Carlo methods based on Markov chains (MCMC), as implemented in the WINBUGS program, version 1.4.3, (Lunn et al., 2000) and which was called from R 2.8.0 (R Development Core Team, 2008). Model convergence was assessed using the *R-hat* statistic (Brooks–Gelman–Rubin statistic in WINBUGS) and effective sample size of the chains (*n.eff* statistic in R) (Brooks and Gelman, 1998). Criteria for convergence were: *R-hat* less than 1.1 and *n.eff* greater than 100 for all the parameters summarized by the model.

In order to obtain the excess number of deaths related with socioeconomic deprivation we calculated the excess of deaths in each census tract comparing observed and expected deaths under the assumption that the deprivation of each area was the same as the average deprivation of the 10% of areas with the lowest deprivation. We defined the excess number of deaths in the ith census tract as (Vergara et al., 2009)

$$\text{Excess deaths in the } i\text{th census tract} = \tilde{O}_i - \tilde{O}_i^*$$

where $\tilde{O}_i$ is the posterior predictive value of observed deaths in the ith census tract and $\tilde{O}_i^*$ the posterior predictive value of expected deaths in the ith census tract.

The counts $\tilde{O}_i$ and $\tilde{O}_i^*$ were estimated using the model B. Specifically

$\tilde{O}_i \sim Poisson(\mu_i)$ where $\mu_i = \exp(\log(E_i)+\alpha+\beta_1 X_i+S_i+H_i)$

and

$\tilde{O}_i^* \sim Poisson(\mu_i^*)$ where $\mu_i^* = \exp\left(\log(E_i)+\alpha+\beta_1 \overline{X}_i^* + S_i + H_i\right)$

with

$\overline{X}_i^* = \frac{\sum_{i\in\delta} X_i}{m}$ where δ represents the subset consisting of the 10% of census tracts with the lowest deprivation index (X_i) and m the number of census tracts in δ.

The total excess of deaths was obtained by summing the excess deaths across all census tracts $\left(\sum_{i=1}^{n}(\tilde{O}_i-\tilde{O}_i^*)\right)$. We have also calculated the percentage of excess of deaths with respect to the total observed deaths $\left(\left(\sum_{i=1}^{n}(\tilde{O}_i-\tilde{O}_i^*)/\sum_{i=1}^{n}(\tilde{O}_i)\right)\times 100\right)$. For each measure we have calculated its posterior mean and 95% posterior credibility interval.

All analyses were conducted separately for each city and for men and women (Kunkel and Atchley, 1996). The geographical distributions of smoothed SMR (sSMR) values derived from the BYM models and of deprivation index are displayed using maps of septiles, green areas representing low sSMR and low deprivation and brown representing high sSMR and high deprivation. All maps were plotted using the R statistical package.

3. Results

Table 1 describes the total population, number of census tracts, and distributions of the population and socioeconomic indicators by census tract, for each city. The number of census tracts varies from 95 (Castellón) to 2358 (Madrid), this number being related with city population. The median population by census tract is around 1000 inhabitants.

In general, Córdoba had the worst, and Barcelona and Bilbao the best levels of socioeconomic indicators. Table 2 shows the number of deaths by cause of death in each city.

For some causes of death, the results showed a similar spatial pattern of the deprivation index and mortality. The geographical distributions of both the deprivation index and the sSMR for several causes of death among men and women in two cities are shown in Fig. 1. We have chosen, as an example, one city where spatial patterns of sSMR and the deprivation index were similar (Valencia) and one that was different (Bilbao).

Tables 3 and 4 show the association between the deprivation index and total and cause-specific mortality, for men and women, respectively. Inequalities in total mortality were highest in Sevilla (RR=1.84) and lowest in Vigo (RR=0.97) for men, and highest in Valencia (RR=1.33) and lowest in Vigo (RR=0.80) for women. Barcelona, Madrid and Valencia were the cities which had more causes with RR higher than 1 for both men and women, while, among women, Castellón, Córdoba and Vigo had almost no RR values different from 1.

Among men, for total mortality, the association was positive and with a credibility interval not including the value of 1 for ten cities. In four causes of death (lung cancer, ischemic heart diseases, respiratory diseases and cirrhosis) the RRs were higher than 1 and with 95% credibility intervals not including this value for the majority of cities. The highest RRs were found in respiratory diseases and cirrhosis. In the case of mortality by prostate cancer and Alzheimer's disease there was no relationship with socioeconomic deprivation in the majority of cities. For the remaining causes of death (diabetes, mental diseases and cerebrovascular diseases) a positive association was only found in a few cities.

Please cite this article as: Borrell, C., et al., Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project). Health & Place (2010), doi:10.1016/j.healthplace.2010.03.002

Table 1
Population, number of census tracts and percentile (P) distribution of population and socioeconomic indicators over census tracts. 11 Spanish cities, 2001.

	Alicante	Barcelona	Bilbao	Castellón	Córdoba	Madrid	Málaga	Sevilla	Valencia	Vigo	Zaragoza
Population	284,580	1,503,884	349,972	147,667	308,072	2,938,723	524,414	684,633	738,441	280,186	614,905
Number of census tracts	222	1491	288	95	224	2358	422	510	598	236	462
Population											
P_{25}	931.3	746.0	895.0	1092.0	1053.5	952.0	962.3	990.3	862.3	962.0	1028.0
P_{50}	1129.0	923.0	1188.5	1457.0	1330.5	1169.5	1180.5	1253.0	1135.0	1174.0	1276.5
P_{75}	1336.8	1166.0	1493.8	1770.5	1621.3	1442.0	1457.0	1612.8	1460.5	1404.5	1566.0
Unemployment (%)											
P_{25}	10.5	8.8	12.2	8.1	18.3	10.4	17.5	17.0	11.9	12.5	9.9
P_{50}	13.5	10.5	14.3	9.4	23.9	12.2	21.1	22.5	14.2	14.6	11.9
P_{75}	16.5	12.7	17.1	10.4	27.6	14.4	24.8	27.6	16.7	16.7	13.7
Low education (%)											
P_{25}	22.8	22.6	21.3	25.7	26.7	18.8	24.6	21.6	21.1	24.8	21.4
P_{50}	33.8	30.8	29.8	33.9	38.5	30.1	33.8	34.3	30.3	33.1	30.7
P_{75}	41.8	39.8	38.7	42.2	49.1	40.8	43.9	46.8	39.6	40.3	38.5
Low education 16–29 years (%)											
P_{25}	7.3	5.3	4.1	9.8	7.4	4.9	8.1	5.8	5.8	6.5	5.7
P_{50}	11.3	8.1	6.8	13.2	11.9	8.6	12.1	10.7	9.5	9.5	8.7
P_{75}	16.2	12.1	11.2	16.9	18.3	13.4	18.1	17.7	12.7	12.6	11.7
Manual workers (%)											
P_{25}	38.7	28.9	29.5	44.6	35.7	27.8	44.1	27.9	32.2	42.1	40.7
P_{50}	56.4	40.2	46.5	56.3	56.8	42.8	60.7	49.2	49.2	55.5	56.7
P_{75}	67.7	52.3	62.0	70.7	68.4	56.4	72.5	67.5	61.7	66.2	66.1
Temporary workers (%)											
P_{25}	22.4	15.3	17.4	20.2	23.7	16.7	28.3	22.9	20.1	22.1	17.8
P_{50}	27.5	18.4	21.4	22.3	31.9	21.5	35.4	29.5	23.7	25.7	21.8
P_{75}	33.6	22.0	25.6	25.0	38.1	25.7	42.2	37.0	27.7	29.9	24.8

P_{25}=25 Percentile.
P_{50}=50 Percentile.
P_{75}=75 Percentile.

For women, total mortality had a high RR with a 95% credibility interval not including the value of 1 in seven cities. However, women's RRs were lower than men's. Lung cancer had an inverse relationship with socioeconomic deprivation in six cities: the higher the deprivation index, the lower the mortality risk. Two causes of death (diabetes and cirrhosis) had a high RR in the majority of cities. Breast cancer in most cities was not associated with the deprivation index, the exceptions being Alicante (RR=1.54; 95%CI: 1.04–2.15) and Vigo (RR=0.54; 95%CI: 0.33–0.83) which presented statistically significant values. Alzheimer's disease had an inverse relationship (RR lower than 1) in three cities, and was not different from 1 in the remaining cities, except Alicante where the RR was 2.10 (95%CI: 1.11–3.85). Other causes of death (mental diseases, ischemic heart diseases, cerebrovascular diseases and respiratory diseases) had RRs higher than 1 in a few cities.

Table 5 shows the number of cases and percentage of excess mortality related with socioeconomic deprivation. Among men excess mortality represented more than 10% of deaths in all cities, except in Vigo, being the total number of excess deaths 59,445; among women the total of excess deaths was 23,292, excess being under 10% for the majority of cities. The highest percentages of excess mortality among men occurred in Madrid (24,505 deaths, representing 22.75% of excess mortality) and, among women, in Valencia (3471 deaths, representing 12.90% of excess mortality).

4. Discussion

4.1. Principal findings and strengths of the study

In the majority of the 11 chosen Spanish cities total mortality presented geographical patterns, in both sexes, that were similar to patterns in the index of socioeconomic deprivation. These geographical mortality inequalities could be explained, at least partly, by socioeconomic deprivation among men and women in the majority of cities. Among men, four specific causes of death (lung cancer, ischemic heart diseases, respiratory diseases and cirrhosis) were positively associated with deprivation in the majority of cities (the higher the deprivation, the higher the mortality). Among women three specific causes of death presented associations, two positive (diabetes and cirrhosis) and one negative (lung cancer). The excess mortality related with socioeconomic deprivation was 59,445 deaths for men and 23,292 for women.

This study has several notable strengths. First, it includes, for the first time, data from eleven Spanish cities from different parts of Spain, representing both the richest and the poorest regions of the country. Second, the statistical analysis performed (hierarchical Bayesian models which take into account the spatial structure) and the choice of a small unit of analysis (the census tract) in urban areas has allowed us to accurately locate those geographical areas having higher mortality risk, while controlling the variability in this indicator for areas of reduced population. Third, the same unit of analysis (census tract) was used in all cities and also a socioeconomic deprivation index was created using the same census-based indicators. Census tracts were chosen because they are small and homogenous areas, with similar socioeconomic characteristics, and they allowed us to reach the objectives of this study. Moreover, studies based on small areas can detect areas with higher mortality and deprivation than is possible in studies based on larger areas. This fact has been described as part of the Modifiable Area Unit Problem, being the variation which can occur when data from area units of one scale is aggregated into fewer units (Waller and Gotway, 2004).

4.2. Interpretation of results

Differences in the range of the socioeconomic deprivation index between cities did not permit categorisation of the index using the same cut-off point in all the cities and for this reason we compared the excess mortality of the 95th percentile with that of the 5th one. The consistency of the results found implies that

Please cite this article as: Borrell, C., et al., Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project). Health & Place (2010), doi:10.1016/j.healthplace.2010.03.002

Table 2
Number and percentages of deaths by cause of death. Men and women, 11 cities in Spain, 1996–2003.

	Alicante		Barcelona		Bilbao		Castellón		Córdoba		Madrid		Málaga		Sevilla		Valencia		Vigo		Zaragoza	
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Men																						
Lung cancer	882	9.2	5896	9.1	1282	8.7	447	8.6	805	8.6	9381	8.7	1335	9.2	2054	9.2	2513	8.7	723	9.1	2077	9.4
Prostatic cancer	246	2.6	1864	2.9	465	3.2	178	3.4	197	2.1	3253	3.0	342	2.4	506	2.3	861	3.0	291	3.7	711	3.2
Diabetes	158	1.6	1289	2.0	266	1.8	110	2.1	212	2.3	1439	1.3	207	1.4	376	1.7	625	2.2	119	1.5	378	1.7
Mental diseases	173	1.8	1566	2.4	298	2.0	76	1.5	174	1.9	1676	1.6	210	1.4	166	0.7	454	1.6	101	1.3	569	2.6
Alzheimer	106	1.1	689	1.1	148	1.0	53	1.0	45	0.5	705	0.7	91	0.6	138	0.6	291	1.0	57	0.7	249	1.1
Ischemic heart disease	1582	16.5	7636	11.8	1487	10.1	715	13.7	1083	11.6	11,484	10.7	1794	12.3	3387	15.3	3745	13.0	856	10.8	2441	11.0
Cerebrovascular disease	682	7.1	4783	7.4	1099	7.5	461	8.8	788	8.4	6457	6.0	1307	9.0	2266	10.2	2220	7.7	502	6.3	1757	7.9
Respiratory disease	589	6.1	3931	6.1	830	5.7	377	7.2	686	7.3	5511	5.1	1242	8.5	1029	4.6	1866	6.5	401	5.0	1320	6.0
Cirrhosis	272	2.8	1552	2.4	393	2.7	102	2.0	282	3.0	2361	2.2	446	3.1	631	2.8	808	2.8	176	2.2	475	2.1
All cause mortality	9609	100.0	64,530	100.0	14,668	100.0	5218	100.0	9370	100.0	107,671	100.0	14,546	100.0	22,206	100.0	28,865	100.0	7941	100.0	22,179	100.0
Women																						
Lung cancer	132	1.6	977	1.5	225	1.7	52	1.2	82	0.9	1533	1.5	146	1.1	216	1.0	339	1.3	116	1.5	249	1.2
Breast cancer	327	4.0	2539	3.9	525	3.9	136	3.0	316	3.6	3972	3.9	479	3.5	849	3.9	1036	3.9	281	3.8	797	3.9
Diabetes	224	2.7	1728	2.6	374	2.7	164	3.7	336	3.8	2274	2.2	351	2.6	633	2.9	834	3.1	199	2.7	621	3.0
Mental diseases	294	3.6	3788	5.8	636	4.7	119	2.7	337	3.8	3956	3.9	499	3.6	388	1.8	1170	4.4	304	4.1	1255	6.1
Alzheimer	175	2.1	1763	2.7	317	2.3	109	2.4	147	1.7	1514	1.5	189	1.4	286	1.3	632	2.4	149	2.0	581	2.8
Ischemic heart disease	1488	18.0	6293	9.6	1056	7.8	551	12.3	933	10.6	9362	9.2	1464	10.6	2956	13.5	2735	10.2	689	9.2	1746	8.5
Cerebrovascular disease	928	11.3	7383	11.2	1539	11.3	591	13.2	1154	13.1	9912	9.7	2202	16.0	3966	18.1	3276	12.2	902	12.0	2283	11.2
Respiratory disease	165	2.0	1507	2.3	386	2.8	127	2.8	228	2.6	1887	1.8	309	2.2	386	1.8	648	2.4	196	2.6	382	1.9
Cirrhosis	153	1.9	1121	1.7	230	1.7	54	1.2	92	1.0	1443	1.4	235	1.7	231	1.1	628	2.3	89	1.2	180	0.9
All cause mortality	8248	100.0	65,628	100.0	13,602	100.0	4483	100.0	8815	100.0	102,085	100.0	13,755	100.0	21,903	100.0	26,892	100.0	7486	100.0	20,460	100.0

International Classification of Diseases (ICD): malignant tumour of trachea, bronchi and lung (ICD9: 162, ICD10: C33, C34); malignant tumour of breast in women (ICD9: 174, ICD10: C50); malignant tumour of prostate (ICD9: 185, ICD10: C61); diabetes mellitus (ICD9: 250, ICD10: E10–E14); ischemic heart diseases (ICD9: 410–414, ICD10: I20–I25); cerebrovascular diseases (ICD9: 430–434, 436–438, ICD10: I60–I69); cirrhosis and other chronic diseases of the liver (ICD9: 571, ICD10: K70, K72.1, K74, K76.1.9).

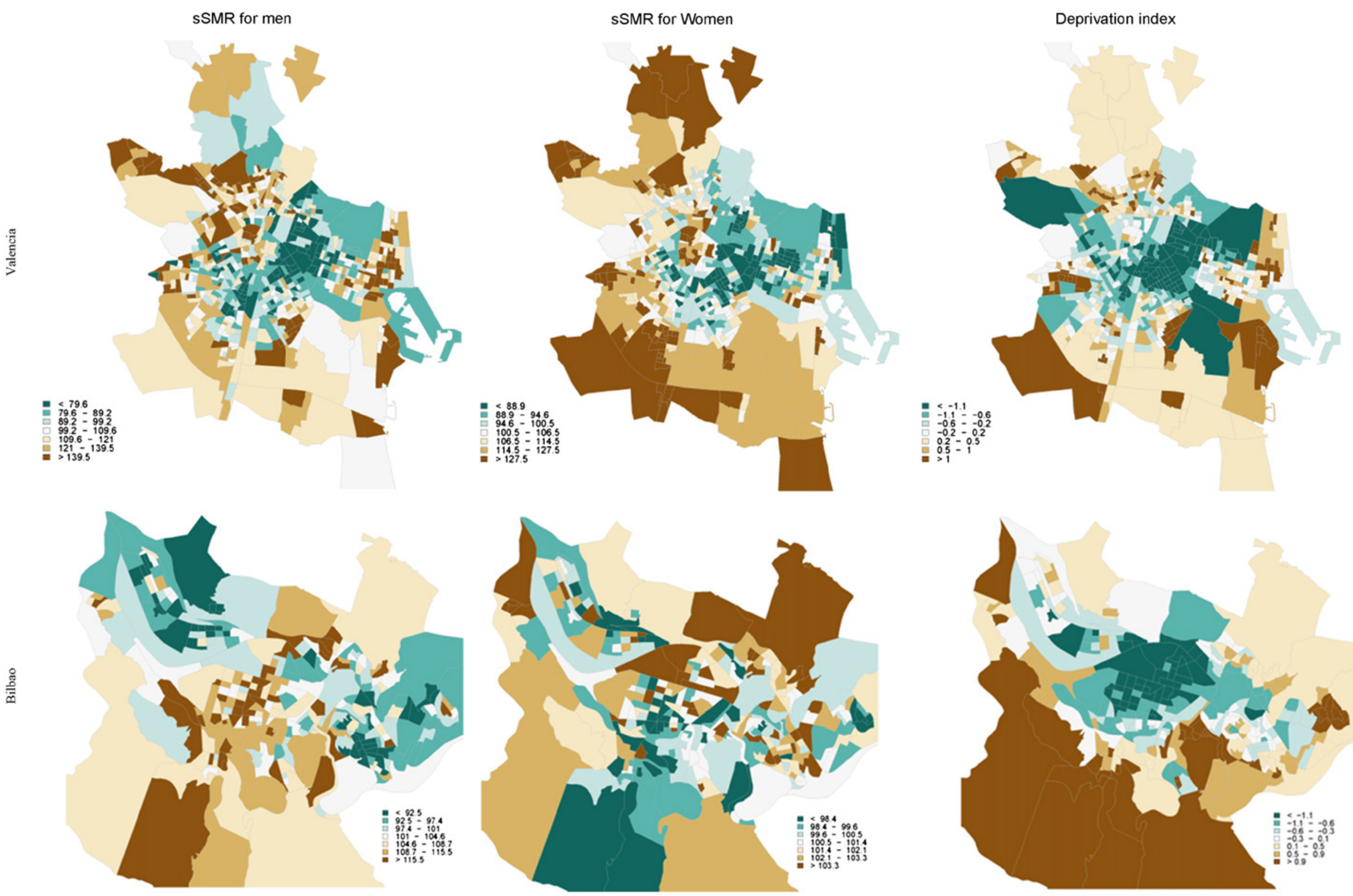

Fig. 1. Distribution of smoothed Standardized Mortality Ratios (sSMR) of respiratory diseases for men and women (Valencia) and prostate cancer for men and breast cancer for women (Bilbao) and of the index of deprivation in septiles. Green areas represent low sSMR and low socioeconomic deprivation. Brown areas represent high sSMR and high socioeconomic deprivation.

Table 3
Association between mortality and the socioeconomic deprivation index. RR comparing 95th to 5th percentile of the deprivation index. Men, 11 cities in Spain, 1996–2003.

Men	Alicante		Barcelona		Bilbao		Castellón		Córdoba		Madrid	
	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
Lung cancer	1.85	1.40–2.40	1.90	1.68–2.14	1.76	1.42–2.14	0.98	0.68–1.38	1.36	1.00–1.83	1.91	1.73–2.10
Prostatic cancer	0.64	0.37–1.04	0.97	0.81–1.15	1.07	0.72–1.55	1.12	0.58–1.89	0.78	0.41–1.32	0.93	0.81–1.07
Diabetes	1.11	0.58–1.96	1.34	1.10–1.63	1.09	0.62–1.78	1.14	0.49–2.18	1.26	0.71–2.04	1.44	1.15–1.79
Mental diseases	1.21	0.64–2.09	1.39	1.09–1.72	1.15	0.66–1.84	1.15	0.37–2.62	1.14	0.52–2.14	1.35	1.11–1.63
Alzheimer	1.00	0.42–1.90	1.05	0.77–1.38	1.05	0.55–1.87	0.84	0.22–2.07	1.03	0.28–2.71	1.22	0.88–1.63
Ischemic heart disease	1.52	1.18–1.98	1.29	1.15–1.44	1.38	1.09–1.74	0.90	0.63–1.24	1.08	0.79–1.45	1.34	1.22–1.45
Cerebrovascular disease	1.59	1.13–2.19	1.28	1.12–1.47	1.02	0.79–1.31	1.27	0.86–1.80	0.94	0.66–1.29	1.29	1.15–1.44
Respiratory disease	2.55	1.77–3.57	2.32	1.97–2.70	2.83	2.19–3.63	1.93	1.28–2.85	1.73	1.18–2.41	2.41	2.13–2.73
Cirrhosis	2.53	1.48–4.09	2.67	2.14–3.25	2.54	1.73–3.58	1.80	0.78–3.67	2.05	1.26–3.18	3.05	2.55–3.58
All cause mortality	1.74	1.45–2.10	1.59	1.50–1.68	1.51	1.36–1.68	1.25	1.05–1.48	1.28	1.01–1.61	1.72	1.64–1.80

	Málaga		Sevilla		Valencia		Vigo		Zaragoza	
	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
Lung cancer	1.79	1.35–2.29	1.88	1.56–2.28	1.52	1.26–1.80	1.05	0.76–1.47	1.47	1.23–1.74
Prostatic cancer	0.90	0.56–1.36	0.87	0.63–1.16	0.97	0.76–1.22	0.80	0.47–1.25	1.03	0.78–1.33
Diabetes	1.50	0.83–2.48	1.45	0.95–2.11	1.44	1.07–1.96	0.82	0.38–1.55	1.32	0.91–1.78
Mental diseases	1.19	0.66–1.99	1.09	0.59–1.86	1.58	1.05–2.22	1.08	0.51–2.03	1.31	0.92–1.81
Alzheimer	0.54	0.20–1.16	0.80	0.40–1.46	0.84	0.51–1.33	1.20	0.36–2.82	1.41	0.91–2.12
Ischemic heart disease	1.36	1.10–1.65	1.37	1.15–1.63	1.35	1.13–1.61	0.74	0.55–0.97	1.16	1.00–1.35
Cerebrovascular disease	1.15	0.93–1.41	1.45	1.17–1.79	1.24	1.02–1.49	1.29	0.86–1.91	1.04	0.86–1.24
Respiratory disease	2.13	1.68–2.67	2.40	1.88–3.09	2.25	1.88–2.67	1.19	0.82–1.71	1.53	1.24–1.88
Cirrhosis	2.28	1.57–3.09	3.79	2.67–5.21	2.11	1.58–2.80	1.37	0.72–2.47	2.53	1.79–3.47
All cause mortality	1.63	1.45–1.83	1.84	1.63–2.07	1.53	1.38–1.70	0.97	0.76–1.20	1.40	1.27–1.53

RR: Relative risk of mortality.
95%CI: credibility interval at 95%.

Please cite this article as: Borrell, C., et al., Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project). Health & Place (2010), doi:10.1016/j.healthplace.2010.03.002

Table 4
Association between mortality and the socioeconomic deprivation index. RR comparing 95th to 5th percentile of the deprivation index. Women, 11 cities in Spain, 1996–2003.

Women	Alicante		Barcelona		Bilbao		Castellón		Córdoba		Madrid	
	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI
Lung cancer	0.47	0.19–1.06	0.82	0.61–1.09	0.55	0.31–0.90	1.04	0.35–2.61	0.35	0.11–0.80	0.75	0.59–0.93
Breast cancer	1.54	1.04–2.15	0.89	0.75–1.07	0.84	0.60–1.14	1.24	0.67–2.28	0.76	0.44–1.18	0.88	0.76–1.01
Diabetes	1.64	0.81–2.97	2.02	1.65–2.39	2.04	1.38–2.90	0.99	0.49–1.81	1.91	1.23–2.78	1.74	1.46–2.06
Mental diseases	1.34	0.79–2.07	1.26	1.04–1.47	1.24	0.89–1.66	1.24	0.52–2.54	0.60	0.31–1.02	1.21	1.02–1.42
Alzheimer	2.10	1.11–3.85	0.85	0.69–1.03	0.55	0.34–0.82	1.03	0.44–2.05	0.70	0.31–1.36	0.70	0.55–0.88
Ischemic heart diseases	1.23	0.96–1.52	1.36	1.20–1.54	1.10	0.84–1.41	0.83	0.54–1.19	1.21	0.85–1.66	1.11	1.01–1.23
Cerebrovascular diseases	1.16	0.88–1.50	1.31	1.20–1.44	1.06	0.86–1.30	0.86	0.57–1.23	0.94	0.68–1.27	1.22	1.11–1.34
Respiratory diseases	1.18	0.58–2.09	1.40	1.09–1.78	1.55	1.03–2.19	1.10	0.50–2.01	1.69	0.97–2.72	1.35	1.09–1.63
Cirrhosis	1.28	0.66–2.26	2.32	1.81–2.93	1.88	1.11–3.01	1.21	0.36–2.95	1.78	0.71–3.67	1.71	1.40–2.07
All cause mortality	1.28	1.09–1.52	1.27	1.19–1.35	1.09	0.96–1.22	1.00	0.82–1.23	1.04	0.82–1.28	1.21	1.14–1.27
	Málaga		Sevilla		Valencia		Vigo		Zaragoza			
	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI	RR	95%CI		
Lung cancer	0.43	0.21–0.77	0.60	0.35–0.96	0.64	0.40–0.95	0.51	0.22–1.03	0.86	0.55–1.30		
Breast cancer	0.84	0.57–1.18	0.87	0.66–1.08	1.04	0.83–1.28	0.54	0.33–0.83	1.20	0.94–1.52		
Diabetes	1.58	1.00–2.34	1.71	1.22–2.32	1.89	1.47–2.35	1.00	0.54–1.70	1.79	1.26–2.48		
Mental diseases	1.47	0.95–2.12	0.87	0.53–1.32	1.50	1.19–1.84	0.97	0.53–1.65	1.15	0.86–1.51		
Alzheimer	0.36	0.17–0.65	0.72	0.46–1.09	1.06	0.79–1.41	0.89	0.38–1.71	0.80	0.55–1.13		
Ischemic heart diseases	1.57	1.26–1.95	1.35	1.13–1.60	1.35	1.16–1.55	0.81	0.57–1.11	1.04	0.84–1.27		
Cerebrovascular diseases	1.49	1.21–1.82	1.08	0.88–1.30	1.22	1.01–1.45	0.94	0.64–1.31	1.06	0.89–1.26		
Respiratory diseases	1.37	0.84–2.10	1.01	0.62–1.52	1.50	1.09–2.01	0.90	0.41–1.60	1.20	0.79–1.76		
Cirrhosis	2.24	1.28–3.50	1.94	1.12–3.08	1.79	1.36–2.33	1.21	0.54–2.31	1.70	1.03–2.67		
All cause mortality	1.32	1.16–1.49	1.19	1.08–1.32	1.33	1.22–1.45	0.80	0.63–1.01	1.17	1.07–1.28		

RR: Relative risk of mortality.
95%CI: credibility interval at 95%.

Table 5
Number of cases and percentage of excess mortality under the assumption that the socioeconomic deprivation of each area was the same as the average socioeconomic deprivation of the 10% of areas with the lowest socioeconomic deprivation. Men and women, 11 cities in Spain, 1996–2003.

Cities	Men				Women			
	Number	95%CI	Percentage	95%CI	Number	95%CI	Percentage	95%CI
Alicante	2039	1394–2720	21.21	14.67–27.83	815	255–1369	9.86	3.04–16.44
Barcelona	11,963	10,480–13,399	18.54	16.24–20.68	6208	4608–7864	9.46	7.00–11.95
Bilbao	2383	1747–3020	16.24	11.99–20.37	436	−266–1093	3.20	−1.96–7.92
Castellón	544	85–991	10.42	1.67–18.61	−16	−519–458	−0.38	−11.98–10.26
Córdoba	946	−16–1807	10.08	−0.17–19.45	115	−854–973	1.29	−9.73–10.85
Madrid	24,505	22,460–26,549	22.75	20.88–24.60	8430	5862–10,699	8.26	5.76–10.42
Málaga	3164	2410–3900	21.74	16.68–26.51	1745	927–2485	12.68	6.71–18.12
Sevilla	4944	4014–5803	22.26	18.16–26.05	1483	559–2332	6.76	2.58–10.60
Valencia	5526	4276–6851	19.14	14.96–23.60	3471	2349–4527	12.90	8.78–16.85
Vigo	−177	−1238–716	−2.24	−15.48–9.03	−957	−2041–77	−12.80	−27.44–1.01
Zaragoza	3608	2621–4570	16.27	11.85–20.36	1562	586–2597	7.62	2.85–12.57

95%CI: credibility interval at 95%.

socioeconomic deprivation is related to mortality regardless of the absolute level of deprivation. Note that the percentage of excess of total number of deaths related with socioeconomic deprivation was not the same in all cities, being higher in Sevilla, Madrid and Málaga among men and higher in Málaga and Valencia among women.

Few studies have analysed socioeconomic inequalities in mortality in urban areas, the majority of these have found a relationship with the socioeconomic levels of the areas (van Lenthe et al., 2005; Stafford et al., 2004) and some of them have described a geographical pattern (Diez Roux et al., 2007; Chen et al., 2006). The ecological associations found probably reflect both the individual socioeconomic position effect as well as a contextual effect of the area. It is worth mentioning that more significant associations have been found in the largest cities, something that may be related with two aspects. First, the existence of larger socioeconomic inequalities in these cities, concentrating areas with high deprivation and worse health outcomes. Second, with more observed deaths and census tracts, there is greater statistical power in these cities; in this sense, the lack of significant results in smaller cities does not necessarily mean that in those cities the effect of deprivation on mortality is negligible, since it could simply be due to a lack of statistical power in those smaller cities.

During the last decade Spain has experienced an increase in immigrants from low income countries who find work in poorly paid occupations. There is substantial evidence indicating that poorly paid immigrants in wealthy countries are assigned jobs that put them at higher risk of ill health than natives, as they are often channelled into informal or precarious employment with greater hazardous exposures (Puigpinos, 2008). However, in the years studied (1996–2003) there were few deaths among immigrants, mainly because they tend to be younger people.

Workplace hazards also raise the possibility of confounding as persons exposed to high risk at work would be more likely to live in deprived neighbourhoods (Muntaner et al., 2004). Unfortunately we did not have data on workplace exposures to determine the relative contributions to mortality of workplace and place of residence. However, area analyses allow us to isolate the populations at risk even if part of the exposures occurs in workplaces located outside the geographical areas studied.

The majority of specific causes that were associated with the socioeconomic deprivation index were related to smoking or alcohol consumption, as has been described for other Spanish studies analysing inequalities between cities (Benach et al., 2001). Smoking-related causes of death among men were lung cancer, ischemic heart diseases and respiratory diseases, whereas among women lung cancer was the only smoking related cause and presented an inverse association (the higher the deprivation, the lower the mortality). This pattern could be explained by the fact that in Spain in the 90s tobacco consumption was higher among men of the more deprived social classes, and among women of the more advantaged classes (Daponte-Codina et al., 2009). In this sense, the pattern of tobacco consumption in Spain, as in other Southern European countries, is in an earlier phase of the smoking epidemic than in Northern European countries, being women of privileged social class who smoke more, a situation that began to change after 2000 (Giskes et al., 2005). These gender differences in smoking patterns are probably also related with the higher excess not only of total mortality but also for the majority of specific causes of death (except for diabetes) for men compared to women. The same pattern has been described in other studies that compared socioeconomic inequalities among men and women of different countries (Mackenbach et al., 1999).

Alcohol consumption is related to cirrhosis mortality. It is possible that areas with higher deprivation are areas where marginalisation and social exclusion exist and specific causes of death such as cirrhosis, AIDS or drug overdose are concentrated (Shaw et al., 1999; Stimpson et al., 2007). The cross-sectional design of our study cannot discard residential mobility (people with heavy alcohol consumption moving to deprived areas). However, this study has found that deprived areas of the cities have excess mortality for many specific causes of death and not only of causes of death more related with marginalisation and extreme poverty.

Diabetes mellitus mortality had a strong relationship with the deprivation index, particularly for women. These findings are in agreement with other studies which have investigated socioeconomic inequalities in diabetes mortality through individual-based analyses and found that the people with higher risk of dying from diabetes are the ones with lower socioeconomic position (Espelt et al., 2008). Inequalities in diabetes mortality may be related with inequalities in diabetes incidence mainly due to inequalities in risk factors of having diabetes such as obesity and also to inequalities in survival of diabetic patients. In the case of men, in many cities there is no relationship between diabetes mortality and the deprivation index. This different pattern by gender could be explained by the larger socioeconomic inequalities in obesity among women (Cavelarrs et al., 1997; Roskam et al., 2010).

Cigarette smoking, alcohol consumption and poor diet are socially approved individual ways to cope with, and temporarily escape, from adverse living conditions. Therefore, these unhealthy behaviours have to be understood in the context of the constraints of poor material conditions of everyday life, and limited access to the fundamental determinants of health (Benach et al., 2001; Shaw et al., 1999; Wallace et al., 2003).

Other specific causes of death were not consistently associated with the socioeconomic deprivation index. However, it is important to highlight the case of breast cancer, where individual positive relationships are described in the literature: the higher the socioeconomic position, the higher the mortality (Strand et al., 2007). In our case, the RRs were around 1 in the majority of cities, indicating no relationship. Similar changes in patterns of breast cancer mortality and incidence by educational level have been observed in Barcelona (Spain) (Puigpinos et al., 2009), New Zealand (Sarfati et al., 2006) and France (Menvielle et al., 2005). A study that analysed inequalities in breast cancer mortality among women in Spanish municipalities found a positive association with the socioeconomic level of the area only among women older than 50 years (Pollan et al., 2007).

4.3. Limitations

One limitation of this study is the change of coding, from the 9th to the 10th revision of the ICD, in 1999. A prior study at national level which analysed agreement between ICD-9 and ICD-10 for the leading causes of death found that differences between classifications were only minor (under 3%) (Cano-Serral et al., 2006). Another limitation is that we have analysed cities, not including the metropolitan areas around them.

4.4. Conclusion and recommendations

This study found a spatial patterning of inequalities in total mortality and mortality by specific causes of death in 11 Spanish cities at the turn of the 21st century. This pattern was related with socioeconomic deprivation in the cities. Future studies will be needed to investigate other specific causes of death and also if the pattern changes by age group. Moreover, we plan to conduct a pooled analysis of all cities in order to analyse the joint smoothing of all the cities, and for every cause of death, in a single model.

The results of this study highlight the importance of intra-urban inequalities in health, a circumstance that policy makers must acknowledge in city health intervention plans in order to appropriately invest resources to tackle these geographical inequalities.

Acknowledgements

This article was partially funded by FIS projects, nos. PI042013, PI040041, PI040170, PI040069, PI042602, PI040388, PI040489, PI042098, PI041260, PI040399, by the CIBER Epidemiología y Salud Pública (CIBERESP), Spain and by the program of "Intensificación de la Actividad Investigadora (Carme Borrell)" funded by the "Instituto de Salud Carlos III" and "Departament de Salut. Generalitat de Catalunya".

This article will be included in the doctoral thesis of one of the authors (Marc Marí-Dell'Olmo), being carried out at Pompeu Fabra University (UPF).

References

Barcelo, M.A., Saez, M., Cano-Serral, G., Martinez-Beneito, M.A., Martinez, J.M., Borrell, C., Ocana-Riola, R., Montoya, I., Calvo, M., Lopez-Abente, G., Rodriguez-Sanz, M., Toro, S., Alcala, J.T., Saurina, C., Sanchez-Villegas, P., Figueiras, A., 2008. Methods to smooth mortality indicators: application to analysis of inequalities in mortality in Spanish cities [the MEDEA Project]. Gaceta Sanitaria/S.E.S.P.A.S 22 (6), 596–608.

Benach, J., Yasui, Y., Borrell, C., Saez, M., Pasarin, M.I., 2001. Material deprivation and leading causes of death by gender: evidence from a nationwide small area study. Journal of Epidemiology and Community Health 55 (4), 239–245.

Besag, J., York, J., Mollie, A., 1991. Bayesian image restoration, with two applications in spatial statistics. Annals of the Institute of Statistical Mathematics 43, 1–59.

Best, N., Richardson, S., Thomson, A., 2005. A comparison of Bayesian spatial models for disease mapping. Statistical Methods in Medical Research 14 (1), 35–59.

Borrell, C., Azlor, E., Rodriguez-Sanz, M., Puigpinos, R., Cano-Serral, G., Pasarin, M.I., Martinez, J.M., Benach, J., Muntaner, C., 2008. Trends in socioeconomic mortality

inequalities in a southern European urban setting at the turn of the 21st century. Journal of Epidemiology and Community Health 62 (3), 258–266.
Borrell, C., Pasarin, M.I., 2004. Inequalities in health and urban areas. Gaceta Sanitaria/S.E.S.P.A.S 18 (1), 1–4.
Brooks, S., Gelman, A., 1998. Alternatives methods for monitoring convergence of iterative simulations. Journal of Computational and Graphical Statistics 7, 434–455.
Cano-Serral, G., Perez, G., Borrell, C., COMPARA Group, 2006. Comparability between ICD-9 and ICD-10 for the leading causes of death in Spain. Revue d'epidemiologie et de sante publique 54 (4), 355–365.
Cavelarrs, A., Kunst, A., Mackenbach, J., 1997. Socioeconomic differences in risk factors for morbidity and mortality in the European community: an international comparison. Journal of Health Psychology, 353–372.
Chen, J.T., Rehkopf, D.H., Waterman, P.D., Subramanian, S.V., Coull, B.A., Cohen, B., Ostrem, M., Krieger, N., 2006. Mapping and measuring social disparities in premature mortality: the impact of census tract poverty within and across Boston neighborhoods, 1999–2001. Journal of Urban Health: Bulletin of the New York Academy of Medicine 83 (6), 1063–1084.
Clayton, D., Bernardinelli, L., 1992. In: Elliott, P., Cuzick, J., English, D., Stern, R. (Eds.), Bayesian Methods for Mapping Disease Risk in Geographical and Environmental Epidemiology: Methods for Small Area Studies. Oxford University Press, Oxford, pp. 205–220.
Daponte-Codina, A., Bolivar-Munoz, J., Ocana-Riola, R., Toro-Cardenas, S., Mayoral-Cortes, J., 2009. Patterns of smoking according to individual social position, and to socioeconomic environment in municipal areas, Spain 1987–2001. Health and Place 15 (3), 679–686.
Diez Roux, A.V., 2007. Neighborhoods and health: where are we and where do we go from here? Revue d'epidemiologie et de sante publique 55 (1) 13–21.
Diez Roux, A.V., Green Franklin, T., Alazraqui, M., Spinelli, H., 2007. Intraurban variations in adult mortality in a large Latin American city. Journal of Urban Health: Bulletin of the New York Academy of Medicine 84 (3), 319–333.
Dominguez-Berjon, M.F., Borrell, C., Benach, J., Pasarin, M.I., 2001. Measures of material deprivation in small area studies. Gaceta Sanitaria/S.E.S.P.A.S 15 (Suppl 4), 23–33.
Dominguez-Berjon, M.F., Borrell, C., Cano-Serral, G., Esnaola, S., Nolasco, A., Pasarin, M.I., Ramis, R., Saurina, C., Escolar-Pujolar, A., 2008. Constructing a deprivation index based on census data in large Spanish cities(the MEDEA project). Gaceta Sanitaria/S.E.S.P.A.S 22 (3), 179–187.
Dominguez-Berjon, M.F., Borrell, C., Lopez, R., Pastor, V., 2005. Mortality and socioeconomic deprivation in census tracts of an urban setting in southern Europe. Journal of Urban Health: Bulletin of the New York Academy of Medicine 82 (2), 225–236.
Espelt, A., Borrell, C., Roskam, A.J., Rodriguez-Sanz, M., Stirbu, I., Dalmau-Bueno, A., Regidor, E., Bopp, M., Martikainen, P., Leinsalu, M., Artnik, B., Rychtarikova, J., Kalediene, R., Dzurova, D., Mackenbach, J., Kunst, A.E., 2008. Socioeconomic inequalities in diabetes mellitus across Europe at the beginning of the 21st century. Diabetologia 51 (11), 1971–1979.
Galea, S., Vlahov, D., 2005. Handbook of Urban Health: Populations, Methods and Practice. Springer, New York.
Gelman, A., 2006. Prior distributions for variance parameters in hierarchical models. Bayesian Analysis 3, 515–533.
Giskes, K., Kunst, A.E., Benach, J., Borrell, C., Costa, G., Dahl, E., Dalstra, J.A., Federico, B., Helmert, U., Judge, K., Lahelma, E., Moussa, K., Ostergren, P.O., Platt, S., Prattala, R., Rasmussen, N.K., Mackenbach, J.P., 2005. Trends in smoking behaviour between 1985 and 2000 in nine European countries by education. Journal of Epidemiology and Community Health 59 (5), 395–401.
Jerrett, M., Buzzelli, M., Burnett, R.T., DeLuca, P.F., 2005. Particulate air pollution, social confounders, and mortality in small areas of an industrial city. Social Science and Medicine (1982) 60 (12), 2845–2863.
Kjellstrom, T., 2008. Our cities, our health, our future. WHO Commission on social determinants of health from the knowledge network on urban settings acting on social determinants for health equity in urban settings, Kobe (Japan).
Krieger, N., 2008. Ladders, pyramids and champagne: the iconography of health inequities. Journal of Epidemiology and Community Health 62 (12), 1098–1104.
Krieger, N., 2003. Place, space, and health: GIS and epidemiology. Epidemiology (Cambridge, Mass) 14 (4), 384–385.
Kunkel, S.R., Atchley, R.C., 1996. Why gender matters: being female is not the same as not being male. American Journal of Preventive Medicine 12 (5), 294–296.
Lawson, A.B., Biggeri, A.B., Boehning, D., Lesaffre, E., Viel, J.F., Clark, A., Schlattmann, P., Divino, F., 2000. Disease mapping models: an empirical evaluation. Disease Mapping Collaborative Group. Statistics in Medicine 19 (17–18), 2217–2241.
Lunn, D., Thomas, A., Best, N., Spiegelhalter, D., 2000. WinBUGS, a Bayesian modelling framework: concepts, structure, and extensibility. Statistics and Computing 10, 325–337.
Macintyre, S., Ellaway, A., 2003. In: Kawachi, B.L., Oxford, I. (Eds.), Neighborhoods and Health: An Overview. University Press, Oxford, pp. 20–42.
Macintyre, S., Ellaway, A., Cummins, S., 2002. Place effects on health: how can we conceptualise, operationalise and measure them? Social Science and Medicine (1982) 55 (1) 125–139.
Mackenbach, J.P., Bos, V., Andersen, O., Cardano, M., Costa, G., Harding, S., Reid, A., Hemstrom, O., Valkonen, T., Kunst, A.E., 2003. Widening socioeconomic inequalities in mortality in six Western European countries. International Journal of Epidemiology 32 (5), 830–837.
Mackenbach, J.P., Kunst, A.E., Groenhof, F., Borgan, J.K., Costa, G., Faggiano, F., Jozan, P., Leinsalu, M., Martikainen, P., Rychtarikova, J., Valkonen, T., 1999. Socioeconomic inequalities in mortality among women and among men: an international study. American Journal of Public Health 89 (12), 1800–1806.
Mackenbach, J.P., Stirbu, I., Roskam, A.J., Schaap, M.M., Menvielle, G., Leinsalu, M., Kunst, A.E., European Union Working Group on Socioeconomic Inequalities in Health, 2008. Socioeconomic inequalities in health in 22 European countries. The New England Journal of Medicine 358 (23), 2468–2481.
Marmot, M., Friel, S., Bell, R., Houweling, T.A., Taylor, S., Commission on Social Determinants of Health, 2008. Closing the gap in a generation: health equity through action on the social determinants of health. Lancet 372 (9650), 1661–1669.
Menvielle, G., Luce, D., Geoffroy-Perez, B., Chastang, J.F., Leclerc, A., 2005. Social inequalities and cancer mortality in France, 1975–1990. Cancer Causes and Control: CCC 16 (5), 501–513.
Muntaner, C., Li, Y., Xue, X., O'Campo, P., Chung, H.J., Eaton, W.W., 2004. Work organization, area labor-market characteristics, and depression among US nursing home workers: a cross-classified multilevel analysis. International Journal of Occupational and Environmental Health 10 (4), 392–400.
Nolasco, A., Melchor, I., Pina, J.A., Pereyra-Zamora, P., Moncho, J., Tamayo, N., Garcia-Senchermes, C., Zurriaga, O., Martinez-Beneito, M.A., 2009. Preventable avoidable mortality: evolution of socioeconomic inequalities in urban areas in Spain, 1996–2003. Health and Place 15 (3), 702–711.
Ocana-Riola, R., Saurina, C., Fernandez-Ajuria, A., Lertxundi, A., Sanchez-Cantalejo, C., Saez, M., Ruiz-Ramos, M., Barcelo, M.A., March, J.C., Martinez, J.M., Daponte, A., Benach, J., 2008. Area deprivation and mortality in the provincial capital cities of Andalusia and Catalonia (Spain). Journal of Epidemiology and Community Health 62 (2), 147–152.
Pollan, M., Ramis, R., Aragones, N., Perez-Gomez, B., Gomez, D., Lope, V., Garcia-Perez, J., Carrasco, J.M., Garcia-Mendizabal, M.J., Lopez-Abente, G., 2007. Municipal distribution of breast cancer mortality among women in Spain. BMC Cancer 7, 78.
Puigpinos, R.(coord), 2008. La salut de la població immigrant de Barcelona. Agència de Salut Pública de Barcelona, Barcelona.
Puigpinos, R., Borrell, C., Antunes, J.L., Azlor, E., Pasarin, M.I., Serral, G., Pons-Vigues, M., Rodriguez-Sanz, M., Fernandez, E., 2009. Trends in socioeconomic inequalities in cancer mortality in Barcelona: 1992–2003. BMC Public Health 9, 35.
R Development Core Team, 2008. R: A Language and Environment for Statistical Computing. R Foundation for Statistical Computing, Vienna (Austria).
Roskam, A., Kunst, A., Van Oyen, H., Demarest, S., Klumbiene, J., Regidor, E., Helmert, U., Jusot, F., Dzurova, D., Mackenbach, J., 2010. Comparative appraisal of educational inequalities in overweight and obesity among adults in 19 European countries. International journal of epidemiology, 39 (2), 392–404.
Rushton, G., 2003. Public health, GIS, and spatial analytic tools. Annual Review of Public Health 24, 43–56.
Sarfati, D., Blakely, T., Shaw, C., Cormack, D., Atkinson, J., 2006. Patterns of disparity: ethnic and socioeconomic trends in breast cancer mortality in New Zealand. Cancer Causes and Control: CCC 17 (5), 671–678.
Shaw, M., Dorling, D., Davey Smith, G., 1999. Poverty, social exclusion, and minorities. In: Marmot, M., Wilkinson, R. (Eds.), Social Determinants of Health. Oxford University Press, Oxford, pp. 211–239.
Shaw, M., Dorling, D., Gordon, D., Davey Smith, G., 1999. The Widening Gap. Health Inequalities and Policy in Britain. The Policy Press, Bristol.
Stafford, M., Martikainen, P., Lahelma, E., Marmot, M., 2004. Neighbourhoods and self rated health: a comparison of public sector employees in London and Helsinki. Journal of Epidemiology and Community Health 58 (9), 772–778.
Stimpson, J.P., Ju, H., Raji, M.A., Eschbach, K., 2007. Neighborhood deprivation and health risk behaviors in NHANES III. American Journal of Health Behavior 31 (2), 215–222.
Strand, B.H., Kunst, A., Huisman, M., Menvielle, G., Glickman, M., Bopp, M., Borell, C., Borgan, J.K., Costa, G., Deboosere, P., Regidor, E., Valkonen, T., Mackenbach, J.P., E.U. Working Group on Socioeconomic Inequalities in Health, 2007. The reversed social gradient: higher breast cancer mortality in the higher educated compared to lower educated. A comparison of 11 European populations during the 1990s. European Journal of Cancer (Oxford, England: 1990) 43 (7), 1200–1207.
UN-Habitat, 2006. State of the World Cities 2006/07. UN-Habitat, Nairobi (Kenya).
van Lenthe, F.J., Borrell, L.N., Costa, G., Diez Roux, A.V., Kauppinen, T.M., Marinacci, C., Martikainen, P., Regidor, E., Stafford, M., Valkonen, T., 2005. Neighbourhood unemployment and all cause mortality: a comparison of six countries. Journal of Epidemiology and Community Health 59 (3), 231–237.
Vergara, M., Martínez, J., Buxó, M., Martín, J., Yasui, Y., Clèries, R., Muntaner, C., Benach, J., 2009. Assessing "extreme amenable mortality" in Spain: a nationally-based time trend small area analysis (1987–2004). In: Vegara, M., Fabra, Universitat Pompeu (Eds.), Causas de "mortalidad prematura evitable". Estrategias de clasificación y aplicación al análisis de la desigualdad geográfica en España, pp. 133–153.
Wallace, D., Wallace, R., Rauh, V., 2003. Community stress, demoralization, and body mass index: evidence for social signal transduction. Social Science and Medicine (1982) 56 (12), 2467–2478.
Waller, L., Gotway, C., 2004. Applied Spatial Statistics for Public Health Data, Hoboken: Wiley; 2004. Wiley, Hoboken.
Whitehead, M., Dahlgren, G., 2006. Concepts and principles for tackling social inequities in health. Levelling up (part 1). World Health Organization: studies on social and economic determinants of population health no. 2, Denmark.

Please cite this article as: Borrell, C., et al., Inequalities in mortality in small areas of eleven Spanish cities (the multicenter MEDEA project). Health & Place (2010), doi:10.1016/j.healthplace.2010.03.002