Area deprivation and mortality in the provincial capital cities of Andalusia and Catalonia (Spain)

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ABSTRACT

Objective: To study the linkage between material deprivation and mortality from all causes, for men and women separately, in the capital cities of the provinces in Andalusia and Catalonia (Spain).

Methods: A small-area ecological study was devised using the census section as the unit for analysis. 188 983 Deaths occurring in the capital cities of the Andalusian provinces and 109 478 deaths recorded in the Catalan capital cities were examined. Principal components factorial analysis was used to devise a material deprivation index comprising the percentage of manual labourers, unemployment and illiteracy. A hierarchical Bayesian model was used to study the relationship between mortality and area deprivation.

Main results: In most cities, results show an increased male mortality risk in the most deprived areas in relation to the least depressed. In Andalusia, the relative risks between the highest and lowest deprivation decile ranged from 1.24 (Malaga) to 1.40 (Granada), with 95% credibility intervals showing a significant excess risk. In Catalonia, relative risks ranged between 1.08 (Girona) and 1.50 (Tarragona). No evidence was found for an excess of female mortality in most deprived areas in either of the autonomous communities.

Conclusions: Within cities, gender-related differences were revealed when deprivation was correlated geographically with mortality rates. These differences were found from an ecological perspective. Further research is needed in order to validate these results from an individual approach. The idea to be analysed is to identify those factors that explain these differences at an individual level.

In one way or another, the socioeconomic features of a geographical area condition the quality of life and health status of the population, to such an extent that the lesser developed areas generally offer fewer social opportunities and present greater health problems than those seen in wealthier areas.[1–3]

Material deprivation in geographical areas has been widely used in ecological studies examining the relationship between social inequalities and health.[4–7] In papers of this kind, the percentage of manual labourers, the percentage of unemployed persons and the percentage of illiterate individuals are often used as indirect measures of material deprivation.[5 8–12]

Using the province or municipality as the unit for analysis, most of those studies conclude that the areas with higher levels of deprivation show excess death and disease.[13–15] These results have played a major role in regional health planning. That kind of study cannot, however, provide details of the extent of health inequalities in urban settings where specific local policies are required. For this purpose, research must be conducted that focuses on the relationship between material deprivation and mortality within cities, using geographical areas smaller than the municipality itself.

Several ecological studies on inequalities in mortality in Spain have shown a relationship between material deprivation and mortality rates within cities using large geographical units.[16–24] Some papers have suggested a greater magnitude of the association in men than in women. The studies were, however, based on large geographical units, where there is a high degree of socioeconomic heterogeneity between individuals. Research in smaller areas where socioeconomic status is relatively homogeneous and spatially organised could clarify the relationship between area deprivation and male or female mortality.

Current approaches in spatial epidemiology suggest that the smallest possible geographical units should be chosen for any study on inequalities in health. This lessens ecological bias as the analysis is closer to the individual level.[25 26] As people with similar socioeconomic characteristics tend to cluster in the same area, there will be an increase in homogeneity in risk factors related to social status within small geographical units, whereas material deprivation measures will be more accurate and geographical correlation studies will be more sensitive to variations in deprivation-related mortality rates.[25]

All Spanish towns are currently divided into census sections. This territorial unit is the smallest area for which aggregated socioeconomic and health information is available. Such administrative subdivision is required to draw up population censuses, for electoral purposes and to perform statistical fieldwork. Each census section includes a maximum of 2000 and a minimum of 500 inhabitants, except for towns with a single section.[27] When urban growth leads to an excessive population increase in a given census section, the affected section is divided into two. This leads to difficulties in monitoring the sociodemographic variables over time at this level of analysis. The census section, however, is now recognised as the most appropriate geographical unit for disease mapping and geographical correlation studies in urban settings.[26]

Andalusia and Catalonia are the two autonomous regions in Spain with the highest population figures, encompassing 34% of the population as a whole.[28] Some capital cities of Andalusia fall within the region of Spain with the highest overall and specific-cause mortality rates.[29] The causes of this excess mortality are not currently understood, highlighting the priority for epidemiological studies in this area. In Catalonia, some capital cities also have excess specific-cause mortality rates compared with Spain or with the autonomous region as a whole,[30 31] although to a lesser extent than in Andalusia.

According to figures provided by the National Institute for Statistics (INE), Catalonia has a per capita income of 24 858 Euros compared with 16 100 Euros in Andalusia, i.e. approximately 54% higher. Andalusia is among the autonomous regions with the lowest per capita income in Spain, whereas Catalonia has one of the highest in the country, even higher than the mean in the European Union.[32] As a result, economic development patterns are fairly disparate in the two regions.

The aim of this paper is to examine the relationship between material deprivation and overall mortality in all census sections of the provincial capital cities of Andalusia and Catalonia, analysing men and women separately. The study forms part of the multicentre AMCAC project.[33]

METHODS

Design

A small-area ecological study was devised using the census section as the unit for analysis. The study was carried out in the provincial capital cities of Andalusia (Almeria, Cadiz, Cordoba, Granada, Huelva, Jaen, Malaga and Seville) and the provincial capital cities of Catalonia (Barcelona, Girona, Lleida and Tarragona; fig 1). A total of 3572 census sections were examined, 1556 in Andalusia and 2016 in Catalonia (table 1).

Study subjects

A total of 188 983 deaths (97 278 men and 91 705 women) occurring in the cities of Andalusia during the 1992–2002 period and 109 478 deaths (55 635 men and 54 113 women) recorded in the cities of Catalonia between 1994 and 2000 were duly examined. The study periods were different in Andalusia and Catalonia as a result of the availability of information sources for each region.

Variables

The number of deaths observed in each city was the dependent variable. Three indicators for material deprivation were used as independent variables: Manual labourers (the number of workers occupied as skilled construction workers, skilled mine and metal workers, skilled workers in other industries, operators of facilities and machinery, unskilled workers and other employees in the services industry per 100 people in employment), unemployment (the number of unemployed per 100 persons in the labour force) and illiteracy (the number of illiterate individuals per 100 people over the age of 10 years).

All information required for this study was taken from the Regional Ministry of Health in each autonomous region and from the 1991 Census. Table 1 provides a summary of the data for each of the 12 cities under study.

Statistical data analysis

A principal components factor analysis (PCFA) was used for each city to summarise the socioeconomic characteristics of the census sections into a single deprivation factor.[34] SPSS software was used for statistical analysis (SPSS Inc., Chicago, Illinois, USA).

Figure 1 Capital cities of the provinces in Andalusia (southern Spain) and Catalonia (northeast Spain).

Table 1 Socioeconomic and demographic characteristics of the provincial capital cities of Andalusia and Catalonia

Region	City	Census sections	Illiteracy	Unemployment	Manual workers	Men		Women	
						Population	Annual deaths*	Population	Annual deaths*
Andalusia	–	–	6%	26%	57%	3 416 291	28 566	3 524 231	27 565
	Almeria	105	4%	24%	34%	75 114	618	80 006	540
	Cadiz	97	2%	28%	31%	74 964	614	79 383	566
	Cordoba	193	4%	27%	40%	145 603	1137	156 551	1055
	Granada	174	3%	24%	27%	120 325	960	134 887	932
	Huelva	88	4%	23%	40%	69 112	521	73 435	480
	Jaen	71	4%	18%	32%	49 890	400	53 370	352
	Malaga	386	4%	29%	38%	251 596	2001	270 512	1876
	Seville	442	3%	25%	33%	327 628	2592	355 400	2535
Catalonia	–	–	2%	12%	43%	2 962 942	26 689	3 096 552	26 095
	Barcelona	1812	1%	15%	28%	775 983	971	867 559	849
	Girona	47	3%	10%	33%	32 994	965	35 662	890
	Lleida	77	3%	12%	34%	54 783	1787	57 310	1659
	Tarragona	80	3%	14%	39%	54 013	1509	56 140	1465
Spain	–	–	3%	19%	22%	19 036 446	178 432	19 835 822	157 997

*Annual mean of deaths in the study period.

A family of hierarchical Bayesian models was used to study the relationship between mortality and area deprivation.[26 35] The following expression thus sets the model:

$$O_m \sim \text{Poisson}\ (\upsilon_m E_m)$$
$$\text{Log}\ (\upsilon_m) = \beta_0 + \beta_1 x_m + u_m + v_m$$

where O_m is the number of observed cases in area m and E_m the age-adjusted number of expected cases using 18 quinquennial age groups. The population in Andalusia and Catalonia for 1991 was taken as the reference benchmark. υ_m Is the relative risk, β_i the coefficients of the model, x_m the value of the deprivation index, v_m a non-structured random term and u_m a structured random term. A specific model was estimated for each city for male and female mortality. Regression coefficients are not strictly comparable between cities because a deprivation index was devised separately for each city by PCFA.

For the random effect modelling non-spatial heterogeneity, it was assumed that, for each area, this term would be conditionally distributed according to a normal distribution. In the same way, the spatial structure was modelled as a conditional autoregressive model. The risk estimate here was obtained by defining a hyperprior gamma distribution over the precision of random effects (inverse of the variance), assuming a uniform distribution for the terms β_0 and β_1 and using Bayesian inference via algorithms Markov chain Monte Carlo.[26 36]

The WinBUGS (MRC, Cambridge, UK and Imperial College of Science, Technology and Medicine, London, UK) software was used for model estimates. The convergence was checked with the Gelman–Rubin diagnostic as modified by Brooks and Gelman.[37] Three parallel chains were run for this purpose.

Using the deprivation coefficient from the random-effect model, comparisons were conducted for mortality rates among deprivation percentile scores, in which the 90th percentile is considered very high on the material privation index and the 10th percentile very low. The relative risk between the highest (d_1) and the lowest (d_2) deprivation decile was thus calculated $e^{\beta 1\ (d1-d2)}$.

RESULTS

For all the cities, PCFA found a single factor that is closely correlated with the percentage of manual labourers, unemployment and illiteracy. The correlation between the factor and each single indicator was greater than 0.9 in all cities. This factor may be interpreted as an indicator of the level of material deprivation in the census sections of each city, accounting for over 84% of the overall variance in data for the cities in Andalusia and over 78% for Catalonia.

Concerning the relationship between material deprivation and male mortality, the regression coefficient for material deprivation was positive in all cities of Andalusia and Catalonia (table 2). In most cities, the 2.5 and 97.5 percentiles of the *a posteriori* distribution of the deprivation coefficient show a credibility interval that excludes zero with 95% probability (table 2). This enables a clear link to be seen between deprivation and mortality in seven cities in Andalusia (Almeria, Cadiz, Cordoba, Granada, Huelva, Malaga and Seville) and two in Catalonia (Barcelona and Lleida). In spite of a major positive association in Jaen and Tarragona, the credibility interval contains the zero value. Girona was the only city where there was no clear evidence of any significant association.

The material deprivation coefficient for female mortality models echoes the finding among male mortality models, although to a lesser extent. This coefficient was positive in most Andalusian cities and two in Catalonia. In principle, this would suggest a direct relationship between deprivation and mortality. The 95% confidence levels also contain the zero value in all estimated models (table 2).

There was an excess male mortality in the census sections with the highest material deprivation when risks were compared between the 90th and the 10th percentiles. In all cities in Andalusia, the relative risks ranged between 1.24 (Malaga) and 1.40 (Granada), with 95% credibility intervals showing a significant excess risk (fig 2). For female mortality, most cities had relative risks above 1, but of a lesser magnitude than among hierarchical models for men and with credibility intervals showing no evidence of an excess mortality in the most deprived areas.

In Catalonia, relative risks for men ranged between 1.08 (Girona) and 1.50 (Tarragona). Credibility intervals showed a major association between deprivation and mortality in Barcelona, Lleida and Tarragona (fig 2). This link was weaker in Girona. As in Andalusia, the relative risks for women were lower than for men, with an *a posteriori* probability distribution that shows no signs of excess risk for the more disadvantaged areas.

Table 2 Area deprivation and mortality relationship in the provincial capital cities of Andalusia and Catalonia

		Men				Women			
		Coefficient*		Variance*		Coefficient*		Variance*	
Region	City	Intercept (β_0)	Deprivation (β_1)†	Structured (u_m)	Non-structured (v_m)	Intercept (β_0)	Deprivation (β_1)†	Structured (u_m)	Non-structured (v_m)
Andalusia	Almeria	−0.03 (−0.08 to 0.02)	0.12 (0.04 to 0.20)‡	0.33 (0.26 to 0.42)	0.23 (0.20 to 0.28)	−0.06 (−0.12 to −0.01)	0.06 (−0.03 to 0.15)	0.35 (0.27 to 0.45)	0.26 (0.21 to 0.31)
	Cadiz	0.05 (−0.01 to 0.11)	0.09 (0.00 to 0.17)‡	0.36 (0.26 to 0.47)	0.27 (0.23 to 0.33)	−0.04 (−0.10 to 0.02)	−0.01 (−0.09 to 0.08)	0.35 (0.27 to 0.45)	0.27 (0.22 to 0.32)
	Cordoba	−0.13 (−0.17 to −0.09)	0.10 (0.04 to 0.16)‡	0.31 (0.25 to 0.38)	0.22 (0.19 to 0.26)	−0.15 (−0.19 to −0.11)	0.03 (−0.03 to 0.09)	0.33 (0.26 to 0.40)	0.23 (0.20 to 0.26)
	Granada	−0.15 (−0.18 to −0.11)	0.13 (0.07 to 0.19)‡	0.29 (0.23 to 0.35)	0.20 (0.18 to 0.24)	−0.16 (−0.20 to −0.12)	0.04 (−0.01 to 0.11)	0.30 (0.24 to 0.37)	0.21 (0.18 to 0.24)
	Huelva	−0.02 (−0.08 to 0.04)	0.09 (0.01 to 0.17)‡	0.34 (0.26 to 0.43)	0.23 (0.19 to 0.28)	−0.10 (−0.16 to −0.04)	−0.01 (−0.09 to 0.07)	0.34 (0.26 to 0.44)	0.24 (0.20 to 0.29)
	Jaen	−0.09 (−0.17 to −0.02)	0.10 (−0.01 to 0.20)	0.44 (0.33 to 0.59)	0.30 (0.24 to 0.37)	−0.07 (−0.15 to 0.01)	0.07 (−0.04 to 0.17)	0.45 (0.33 to 0.61)	0.31 (0.25 to 0.38)
	Malaga	−0.01 (−0.03 to 0.02)	0.08 (0.05 to 0.11)‡	0.25 (0.21 to 0.30)	0.19 (0.17 to 0.21)	−0.04 (−0.07 to −0.02)	0.02 (−0.02 to 0.05)	0.26 (0.21 to 0.31)	0.19 (0.17 to 0.22)
	Seville	−0.10 (−0.12 to −0.07)	0.09 (0.05 to 0.12)‡	0.30 (0.24 to 0.36)	0.21 (0.18 to 0.23)	−0.15 (−0.18 to −0.13)	0.01 (−0.03 to 0.05)	0.29 (0.24 to 0.40)	0.21 (0.18 to 0.23)
Catalonia	Barcelona	−0.11 (−0.13 to −0.06)	0.04 (0.00 to 0.09)‡	0.58 (0.47 to 0.70)	0.38 (0.34 to 0.41)	−0.10 (−0.12 to −0.05)	−0.02 (−0.07 to 0.03)	0.58 (0.45 to 0.72)	0.40 (0.36 to 0.45)
	Girona	−0.15 (−0.21 to −0.01)	0.03 (−0.09 to 0.15)	0.26 (0.01 to 0.60)	0.21 (0.04 to 0.33)	−0.16 (−0.22 to −0.01)	−0.03 (−0.14 to 0.09)	0.26 (0.01 to 0.68)	0.24 (0.02 to 0.37)
	Lleida	0.08 (−0.01 to 0.13)	0.11 (0.01 to 0.22)‡	0.46 (0.13 to 0.80)	0.31 (0.16 to 0.43)	0.02 (−0.05 to 0.07)	0.06 (−0.05 to 0.18)	0.49 (0.14 to 0.84)	0.34 (0.20 to 0.47)
	Tarragona	−0.02 (−0.05 to 0.01)	0.16 (−0.01 to 0.33)	0.53 (0.07 to 0.96)	0.42 (0.24 to 0.57)	−0.01 (−0.04 to 0.02)	0.11 (−0.04 to 0.27)	0.32 (0.02 to 0.80)	0.48 (0.34 to 0.61)

*Mean of the posterior distribution (2.5 and 97.5 percentile of the posterior distribution in parenthesis).
†Regression coefficient. A positive value means that as the deprivation increases, the relative risk increases. A negative value indicates that as the deprivation increases, the relative risk decreases. For every increase of one unit in deprivation index, the mortality risk changes by e^{β_1}.
‡Area deprivation and mortality association with probability 0.95.

The components of variance from the model in all cities of both Andalusia and Catalonia predominantly showed a structured random effect (table 2). The variation in relative risk that cannot be accounted for by material deprivation in the areas is, therefore, largely attributable to an underlying spatial structure still present.

DISCUSSION

Spatial epidemiolgy concerns the analysis of the geographical distribution of health indicators and their correlation with respect to demographic, socioeconomic and environmental factors at a small-area level.[26] It is well known that this kind of ecological study should be conducted at appropriate spatial scales, depending on the occurrence and particular spatial structures of disease. Discussions on the size of the geographical unit areas first appeared in scientific literature in the 1960s. The census section is now recognised as the optimal area for monitoring inequalities in health.[26 38]

Despite a large number of studies examining the relationship between material deprivation and mortality, there is no consensus regarding the optimal method for measuring deprivation in small areas.[8 39] Currently, the most widely used are the scores proposed by Townsend *et al*[4] and Carstairs and Morris[5] although it is not always possible to reproduce the original method in Spain and other European countries given that the features of the databases available are very different from those used in countries such as the United Kingdom.[7]

For the purpose of this study, a method based on PCFA was used to devise a material deprivation score comprising the percentage of manual labourers, unemployment and illiteracy. Other variables, such as ownership of the main home, crowding, per capita income and ownership of a private vehicle, which may be linked to the concept of deprivation, were not available in Spanish statistical information systems for the census section scale for the period under study. As a result, the score devised is, in this case, the best approximation for measuring deprivation applicable for areas smaller than the municipality. This composite index has greater validity, robustness and explanatory power than a single indicator, as well as reflecting the multidimensional characterisation of a geographical area more accurately.[39 40]

The results show a relationship between material deprivation in the census sections and male mortality, with the highest mortality rates arising in the most depressed areas. This effect was seen in general terms in almost all cities in Andalusia and Catalonia.

This relationship is weaker for female mortality. Although the majority of cities show an excess risk in areas with greater deprivation, the magnitude of this effect is less than for male mortality and the *a posteriori* probability distribution shows no clear evidence of an association.

Ecological studies conducted in the past, both in Spain and other European countries, used larger geographical units than the census section, as well as different statistical methods and disparate indicators of material deprivation, thus hindering any strict comparison of results. Even so, all those papers reported higher overall and specific-cause mortality rates in the most depressed areas and also suggested a different magnitude of association between deprivation and mortality for both genders.[16–24 41] Their conclusions were similar to those drawn in this paper.

The very few studies recently published in Spain that used the census section as the geographical unit for analysis also showed similar results to those for the cities in Andalusia and

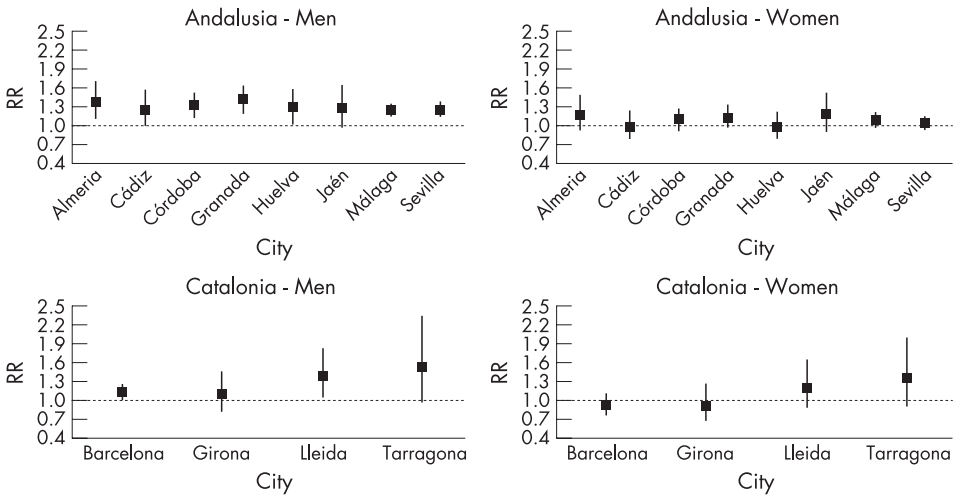

Figure 2 Relative risk and 95% credibility interval between the highest and lowest deprivation decile. RR, Relative risk.

Catalonia.[42 43] In the light of these findings, there seem to be consistent results confirming higher male mortality rates in the more depressed areas. There is, however, no evidence of a relationship between deprivation and female mortality rates, even using the smallest geographical unit currently available in urban settings.

There is no consensus as to the underlying reasons that may account for this finding. The first issue that must be addressed involves some kind of epidemiological bias.

The main bias in classification that may be present in ecological study designs of this kind stems from assigning deaths occurring in a given census section to another section. This would not, however, entail any differential between areas of greater or lesser material deprivation and there is no reason to think either that such errors occur more frequently for men or for women. In Spain, there has been no thorough study to date on the quality of completion of address details on statistical death reports. Such specific individual studies to rule out the hypothesis of classification biases of this kind, together with a detailed analysis of migratory flows, are becoming increasingly vital to ensure reliability in small-area studies.[44]

The results of this study also raise other areas for consideration apart from a possible epidemiological bias. The findings show very similar patterns of association between overall mortality and material deprivation in two autonomous Spanish regions, one with a high economic level and another less developed region. Two further issues arising from the findings are also of importance. First, the relationship between mortality and deprivation appears to behave similarly even in cities with different income levels. Second, the relationship between material deprivation and mortality is different for both genders within the same city.

Girona is the exception to this rule, where there is no evidence of a relationship between material deprivation and male or female mortality, which may be a result of the homogeneous distribution of material deprivation throughout all the census sections in the city.

Perhaps the difference in results between male and female mortality may be caused by other contextual factors related, to a greater or lesser extent, to deprivation in the different census sections. In fact, the underlying spatial structure still present in hierarchical models after having included material deprivation reinforces this hypothesis. In any event, it is far from easy to account for these findings without support from individually based studies that do not fall into the ecological fallacies inherent in this kind of study.

The characteristics of both the area itself and the environment in which individuals live may have different effects on men and on women.[7 45–47] A recent study in Spain showed that men's health was mainly affected by working conditions, whereas family circumstances and other gender-related factors had a substantial impact on women as well as their working conditions.[48 49] Both the characteristics of an individual and his/her environment are of importance when accounting for health

What is already known on this subject

- Research on health inequalities within cities is essential to devise local health policies aimed at improving the health of the population in the most depressed areas.
- During the past decade, several papers suggested a greater magnitude of association between deprivation and mortality rates in men than in women, a surprising result that has led to lengthy discussions.
- All those studies were performed using large geographical areas. The relationship between material deprivation and male and female mortality could, however, differ using the census section as the geographical unit for analysis, in which socioeconomic status is relatively homogeneous and spatially organised.

What this paper adds

- Despite divergent economic development in Andalusia and Catalonia, both regions' cities show a similar pattern in the link between mortality and material deprivation.
- The relationship between material deprivation and mortality is different for both genders. In most cities, results show an increase in male mortality rates in the most deprived areas. No evidence was, however, found for an excess of female mortality in those areas.
- Even using the smallest geographical unit currently available for urban settings, the conclusions are similar to those published in the past using larger geographical areas.

Policy implications

- These findings suggest that local intervention strategies aimed at reducing male mortality in the least advantaged areas should be implemented.
- Research at the individual level must be continued to validate whether the risk of death is higher in men than in women in more deprived areas and to identify risk factors for mortality among men and women in urban settings.

status. Over the past few years, the simultaneous use of both these kinds of variables, together with an analysis of their interactions through multilevel models, has provided a major area for research that continues to develop currently.[50]

This research at the individual level must be continued to validate whether the risk of death is really higher in men than in women in more deprived areas, and to identify risk factors for mortality among men and women in urban settings.

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