Deaths in collective dwellings and inequalities in small-area mortality: an ecological study in the Madrid region (Spain

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Abstract

Background: There are increasing numbers of elderly persons who reside and die in institutions, yet there are few studies that analyse the effect of this on mortality in small areas and its ensuing effect on the association between material deprivation and mortality.

Methods: Cross-sectional, ecological study **in the Region of Madrid** covering 3906 census tracts (median of 1000 inhabitants), using mortality data for 1996-2003, and socioeconomic deprivation from the 2001 census. Standardised mortality ratios (SMRs) were calculated for each census tract. Using the Besag-York-Mollié model, relative risks (RRs) of dying and their 95% credibility intervals (CIs) according to the deprivation index considered (with the fourth quartile, Q, being the most unfavourable situation) were calculated for deaths among: the total population; and the population excluding residents who died in institutions .

Results

A total of 6% of the deceased had been residing in institutions, that affected 16.5% of census sections (644) and accounted for 17% of the variability in SMRs among men and 10% among women, $p<0.001$. Mortality increased with socioeconomic deprivation, i.e., whereas the RRs for the total population in Q4 with respect to Q1 were 1.46 among men (RR 95% CI 1.41-1.50) and 1.12 among women (RR 95% CI 1.08-1.17), these figures rose to 1.48 (95% CI 1.43-1.53) and 1.14 (95% CI 1.10-1.18) respectively for the population excluding residents who died in institutions.

Conclusions

We found that deaths of residents in institutions affect variation in small-area mortality, and confound the relationship between mortality and socioeconomic deprivation. This variable should be recorded in mortality statistics so that its effect can be controlled for in subsequent analyses.

WHAT IS ALREADY KNOWN

- Geographical distribution of life expectancy and standardised mortality ratios in small-sized populations and small areas is linked to the location of nursing-homes.
- No relationship has been observed between deaths in these homes in small areas and socioeconomic deprivation.
- There is a need for studies that use different methodologies and target larger-sized populations to confirm the impact of such homes on other mortality measures.

WHAT THIS STUDY ADDS

- In a large-sized population such as that of the Madrid region (*Comunidad de Madrid*), this study confirms the relationship between the standardised mortality ratio in small areas and residential deaths in old age **and nursing-homes, prisons, and psychiatric and geriatric hospitals** ,with men and women being affected to different degrees.
- The impact of old age and nursing-homes deaths, **prisons, and psychiatric and geriatric hospitals** on the relationship between mortality and socioeconomic deprivation is quantified.
- The proportion of deaths in old age and nursing-homes**, prisons, and psychiatric and geriatric hospitals,** must be taken into account when it comes to interpreting small-area mortality.

Background

From a descriptive standpoint, geographical representation of a population's health status is a basic tool because it enables areas with a greater need for intervention to be identified, and planning guidelines for preventive or health-care measures to be drawn up. Furthermore, interpretation of spatial variation in any health phenomenon is useful for generation of aetiological hypotheses about the risk of falling ill.(1)

Ecological studies that analyse health status by small areas have witnessed growing interest in recent years, paralleled by the development of geographic information systems, statistical methods and software infrastructure. Nevertheless, presenting their results in a way that serves the needs of health policy makers is a problem for researchers.(2) Such studies pose important methodological challenges. Sources of bias in spatial epidemiology are numerous and complex, and thus call for prudence in the interpretation of results. Specifically, migrations tend to result in underestimation of the effect.(3)

As populations age, demand for residential care or institutional settings continues to rise. This fact is of particular interest in small-area studies, since it may give rise to excess mortality in areas with a high percentage of the population living in old people's homes, a finding that is open to misinterpretation Although its effect was described twenty years ago, (4) there are few studies which show that migration of frail individuals to long-stay residences affects geographical variation in health problems, thereby leading to a bias in estimates.(2;5-9) The indicators that have been

studied are life expectancy and standardised mortality rates, though more studies are called for to examine this topic in depth, using larger-sized populations and applying different methodologies.(2;8)
This study formed part of the so-called MEDEA project (socioeconomic and environmental inequalities in small areas of Spanish cities) and was aimed at quantifying the effect that deaths of residents in collective dwellings (mostly old age and nursing-homes) have on mortality rates, and its ensuing effect on the relationship between mortality and socioeconomic deprivation. Bearing in mind that 78% of the population who live in such homes are women, (10) interest attaches to studying gender-related differences.

Methods

Study design and data

This was a cross-sectional ecological study, with the units of analysis being 3906 census tracts in the Madrid region, an area having a total population of 5,423,384 (2001 Census). A census tract is a territorial unit that is fundamentally defined by population volume criteria and delimited by territorial features, both geographical and urbanistic. Its small size (median population of around 1000 inhabitants) favours homogeneity. The Madrid region has an essentially urban nature, with 54.2% of the population living in the city of Madrid and 40.0% in the surrounding Greater Madrid metropolitan area.
Individual mortality data for 1996-2003 (n=305,343) were supplied by the Madrid Regional Statistics Institute (*Instituto de Estadística de la Comunidad de Madrid*). Based on the deceased's domicile, postal addresses were geocoded and assigned to the pertinent 2001 census tract. Geocoding was accurate in 95.6%, roughly approximate in 2.7%, and estimated in 1.7% of entries.
Based on these data, we were able to ascertain whether the deceased resided in a collective or family dwelling, and create the variable, "collective", for deaths in group settings (old age homes, nursing-homes, prisons, and psychiatric and geriatric hospitals). In terms of type of collective dwelling, these were old age or nursing-homes in 92.4%, hospitals (geriatric or psychiatric) in 6.2%, and prisons in 1.4% of cases. This, in turn, enabled us to work with total deaths for the study period and, by extracting the deaths of residents in collective dwellings, calculate the small area mortality for these two populations.
Census-tract populations, for the whole population and for residents in family dwellings, broken down by age group (19 groups) and sex, were drawn from the 2001 census, the year approximately corresponding to the midpoint of the study period. Person-years for the period were estimated by multiplying the above populations by 8.
Based on family-dwelling data in the 2001 population and the household census, we drew up indicators, and the deprivation index defined in the MEDEA Project was used and calculated for the Madrid region.(11)This index was calculated by principal components analysis, the component parts of which were: unemployment, temporary workers, manual workers and low educational level among both the overall adult (age ≥16 years) and young adult (age 16-29 years) populations. **The index accounts for more than 75% of component's variability**. This deprivation index follows a distribution with a mean of 0 and a standard deviation of 1, in which the highest values indicate the most unfavourable situation. The quartiles of the index were calculated (with the fourth quartile being the most unfavourable situation).

Analysis

Standardised mortality ratios (SMRs) for each census tract, were calculated as the ratio between observed and expected deaths.Expected cases were computed, taking Spanish total mortality rates for 2001, broken down by age group and sex, as reference.

We studied the relationship between the percentage of deaths in collective dwellings and SMRs, using linear regression, calculating the coefficient of determination to estimate the variability due to this variable.

Applying the methodology of analysis proposed for the MEDEA project, (12) the relative risk of mortality (RRs) was calculated by quartile of the socioeconomic index, for deaths, both overall and after the exclusion of those which occurred in collective dwellings. MEDEA project used a bayesian hierarchical model, in order to reduce the extravariability involved in using SMR. Relative risks were calculated using the autoregressive conditional model developed by Besag, York and Mollié.(13) This is a Poisson spatial model with observed cases for each census tract as the dependent variable, expected cases as offset, and two random effects terms that take the following into account: the effects which vary in a structured manner in space (census tract contiguity); and a component that models the effects which vary among census tracts in an unstructured manner (census tract heterogeneity).

A conditional autoregressive model (CAR) was used for the spatial effect. The non-spatial random effect is assumed to be distributed normally with a zero mean and constant variance. This method, which is the most usual and computationally most simple, approaches the spatial dependence as an average of the spatial effect of its neighbouring areas. The areas considered are the census tracts of the region of Madrid, and the neighbouring areas are the adjacent census tracts.

For the prior distribution for the random effects for the model parameters, and the standard deviations, we chose ‘vaguely’ or ‘weakly’ informative priors distributions .In particular, a uniform distribution in a finite range (0 to 5) of the standard deviation both of the spatial random effects (spatial dependency) and the unstructured random effects (non-spatial heterogeneity). [12]

The deprivation index in quartiles were included in the model as explanatory variable to examine, from a a geographical and ecological point of view, its relationship with mortality.The models were fitted using Bayesian Markov chain Monte Carlo simulation methods. Posterior distributions of RRs were obtained using WinBugs 1.1.4,(14) invoked from R.(15) To this end, three Markov chains were performed, using 50000 iterations, with 10% being discarded as "burn-in" and 1 out of every 90 simulations being retained. The Brooks-Gelman-Rubin Statistic (R-hat) was used to analyse the convergence of the chains, and the effective sample size of the chains (n.eff) to control for autocorrelation. Convergence criteria were: R-hat of under 1.1; and n.eff of over 100.

RESULTS

Over the eight years of the study period (1996-2003), 6% of the population died in collective dwellings (n=18,399), which affected 16.5% of the census sections (n=644) in the Madrid region In 30% of these (n=193), at least 20% of deaths took place in collective dwellings, which accounts for 5% of all sections. Distribution by sex and age indicated that 67% were women and 5.6% were aged under 65 years. With respect

to geographical location, the greatest proportion of these deaths occurred outside the city of Madrid, and indeed, among women, this proportion was three times higher than that observed in the city (16% versus 5% respectively) (Table 1).

Table 1 - Deceased Population in collective dwellings[1] by age, sex and geographical setting. Region of Madrid, 1996-2003

	Madrid region		Madrid city		Remainder of the region	
	N	%	N	%	N	%
Age						
0-64	1039	5.6[2]	618	8.0	421	4.0
65-79	3277	17.8	1438	18.6	1839	17.3
80-94	12256	66.6	4903	63.3	7353	69.0
>=95	1827	9.9	782	10.1	1045	9.8
Total	18399	6.0[3]	7741	3.7	10658	11.2
Men	6060	3.8	2631	2.4	3429	6.8
Women	12339	8.4	5110	5.0	7229	16.1

[1]Colletive dwellins include old age and nursing-homes deaths prisons, and psychiatric and geriatric hospitals
[2] Column percentage
[3] Percentage of total deaths

The profile of causes of death observed in collective dwellings compared to the pattern in the general population shown that collective dwellings displayed excess mortality due to cardiovascular diseases, respiratory tract diseases, mental disorders and diseases of the nervous system (dementias), and a comparatively lower mortality due to tumours (data not shown).

Deaths in collective dwellings and standardised mortality ratio

Figure 1 depicts linear regression between the SMR and the percentage of deaths in collective dwellings, by sex. The percentage of deaths in collective dwellings accounted for 17% and 10% of the variability in mortality by census section in the total population, among men and women respectively ($p<0.001$).

Socioeconomic deprivation index and deaths in collective dwellings

Insofar as the relationship between the socioeconomic deprivation index and the percentage of deaths in collective dwellings was concerned, we observed an inverse and significant Pearson correlation between the two variables of: -0.10 ($p=0.02$) among men; and -0.12 ($p=0.005$) among women**. The collective dwellings tend to be**

located in census tracts with higher income level, leading to a confounding effect between the area-level mortality and the area-level socioeconomic deprivation.

Socioeconomic deprivation index and mortality

In the case of the relationship between mortality (SMR) and the socioeconomic deprivation index, there was a positive linear association between both indicators, with a coefficient of determination among men of 9.1% for mortality in the overall population, which rose to 13% for mortality in the population excluding residents who died in collective settings ($p<0.001$). This association was weaker among women, 0.07% ($p=0.06$) in the overall population, rising to 1.4 ($p<0.001$) after exclusion of the group of deaths in collective dwellings (Figure 2).
Table 2 shows the RRs of mortality by quartile of the deprivation index, for the population as a whole, and the population excluding residents who died in **collective dwelings.** Mortality was observed to rise as deprivation increased, with an excess mortality of 46% in men and 12% in women for the most underprivileged quartile vis-à-vis the best situation. These percentages rose to 48% and 14% respectively when deaths in collective dwellings were excluded, with an increase in the magnitude of RRs being observed across all quartiles.

Table 2 – Risk of mortality by quartile of the socioeconomic deprivation index, in the total population and in the population excluding residents who died in collective dwellings.Region of Madrid, 1996-2003

	Total population			Total population excluding residents who died in collective dwellings		
	RRs[a]	95% CI[b]		RRs	95% CI[b]	
	Men			Men		
Deprivation index						
Q1	1			Q1	1	
Q2	1.14	1.11	1.17	Q2	1.16	1.13 1.19
Q3	1.27	1.23	1.31	Q3	1.29	1.25 1.33
Q4 [c]	1.46	1.41	1.50	Q4	1.48	1.43 1.53
	Women			Women		
Q1	1			Q1	1	
Q2	1.02	0.99	1.06	Q2	1.03	1.00 1.06
Q3	1.06	1.02	1.10	Q3	1.07	1.03 1.10
Q4	1.12	1.08	1.17	Q4	1.14	1.10 1.18

[a] RRs: RR deprivation (exp(β))

[b] 95% CI*: 95% Credibility Interval

[c] Q4: quartile with greatest socioeconomic deprivation

Discussion

This study, undertaken in the Madrid region, quantifies the effect exerted on small-area mortality rates by deaths of residents in collective dwellings (old age or nursing-homes in the vast majority of cases). The magnitude of mortality rates was seen to increase as the percentage of deaths in **collective dwellings** rose. Rather than taking place at random locations, deaths in collective dwellings in the region tended to occur predominantly outside the city of Madrid and in sections with a slightly higher economic level. Lastly, this study show the way in which this group of deaths confounds the relationship between mortality and socioeconomic deprivation~~,~~

The Madrid region is fundamentally urban and economically determined by the city of Madrid, where 54% of its population lives. The geographical location of deaths in collective dwellings indicates that, among those occurring outside the city limits, women predominate, with a percentage that is three times higher than the rest of the region, i.e., 16% versus 5% respectively. The migration of older adults from the city of Madrid to old people's homes on the outskirts is also to be seen in the fact that, while 69% of the Madrid regional population dies in the city of Madrid, only 42% of all deaths in collective dwellings occur in the city.

The relationship between sections with highest mortality and those with the greatest proportion of deaths in old age homes, as well as the causal link between the two, become manifest when this relationship disappears, i.e., when the deaths of residents in collective dwellings are excluding from the analysis. This is explained by the greater frailty and the concentration of elderly in such homes~~.~~ leading to a bias in the estimates. (2;5;7;8) Accordingly, the smaller the area of analysis, the greater the magnitude of this bias, with this being particularly evident in areas in which the percentage of deaths in old age homes exceeds 20% of total deaths, (7) in our particular case, 5% of all census sections. This ecological bias does not appear, however, when each unit of analysis includes the old age homes that cater for the local elderly population, thereby preventing this population's migration, such as what happens at a provincial level. (2)

The description of deaths in collective dwellings by sex and cause of death indicates a predominance of female mortality due to cardiovascular diseases and dementias, the area of mortality sure to be most affected when total deaths are included, and in such a case, special care will therefore have to be taken in interpreting small-area mortality data.

Sources of bias in spatial epidemiology are numerous and complex, and prudence is thus called for in the interpretation of results. Currently, census sections are acknowledged as being the optimal geographical areas for studying spatial variability in health outcomes in cities, drawing up and evaluating health policies, and studying socioeconomic inequalities in health. (16;17)

Specifically, migrations and errors in classification of exposure tend result in underestimation of the effect. In this study, control for this effect led to a discrete increase in RRs of 2% to 3%, owing to the fact that **collective dwellings** are found in sections with a slightly higher socioeconomic level than the rest. This association could also arise in other European regions which have large metropolitan centres that dictate their economic and population dynamic, and collective dwellings situated on the outskirts.

The percentage of older adults living in collective dwellings in Spain (2.3%) is below the European mean. (18) In the Madrid region, this percentage was 2.7% in 2006. The breakdown of residential places on offer is as follows: 98.8%, old age and nursing-

homes; and 1.2%, alternative accommodation systems (sheltered housing or public-funded fostering scheme whereby families take in elderly tenants). (10)
The social context of slow yet progressive ageing of the population -particularly the increase in the 80-84 and over-85 age groups, which generates a worsening in dependency factors- can be expected to lead to a notable increase in the need for residential places.(19) Accordingly, these data lead us to think that the effect of these deaths on the observed spatial mortality pattern could be intensified in the next few years and so lend this study heightened interest.
Among this study's limitations is the possible underestimation of deaths in old age homes due to problems in the assigning of postal addresses and the need to use populations in family dwellings based on the 2001 census, which could result in biases in the numerator and the denominator. Furthermore, the calculated SMRs are slightly underestimated because reference rates are the total Spanish population not excluding deaths in colective dwelling. In this sense, the problem with removing the dead in **collective dwellings** is that rates are not comparable with the rates obtained with the entire population. Maybe its randomization by geographic units could solve both problems: the bias and the comparability.
The proposed deprivation index has been constructed with data from large cities. It may not be appropriate to use the same type of indicators of deprivation in rural settings, because their meaning may be different. However, as mentioned earlier,the region of Madrid has an essentially urban nature, and only 5.8% of the population live in rural locations.
Moreover, the study's cross-sectional design means that trends in the respective population groups are not taken into account.
In this regard, improvement in studies calls for a considerable investment in better data availability and quality,(3) and the usefulness of death statistics is linked to continuous improvement in quality as well as the ability to respond to new information needs.
The results of this study point to the importance of taking into account the elderly migration in the study of mortality, and the relationship between this and small-area inequalities, important question to policymakers. A variable should therefore be included in death statistics, which would enable this population group to be addressed in the analysis. In this respect, in January 2009 the Spanish National Statistics Institute approved and implemented a reform project designed to enhance the quality of death statistics.(20) This would require a record to be kept of whether the place of death was a old age home, something that, in the near future, would make it possible for mortality in this population subgroup to be analysed separately.

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Conflicts of interest: none.

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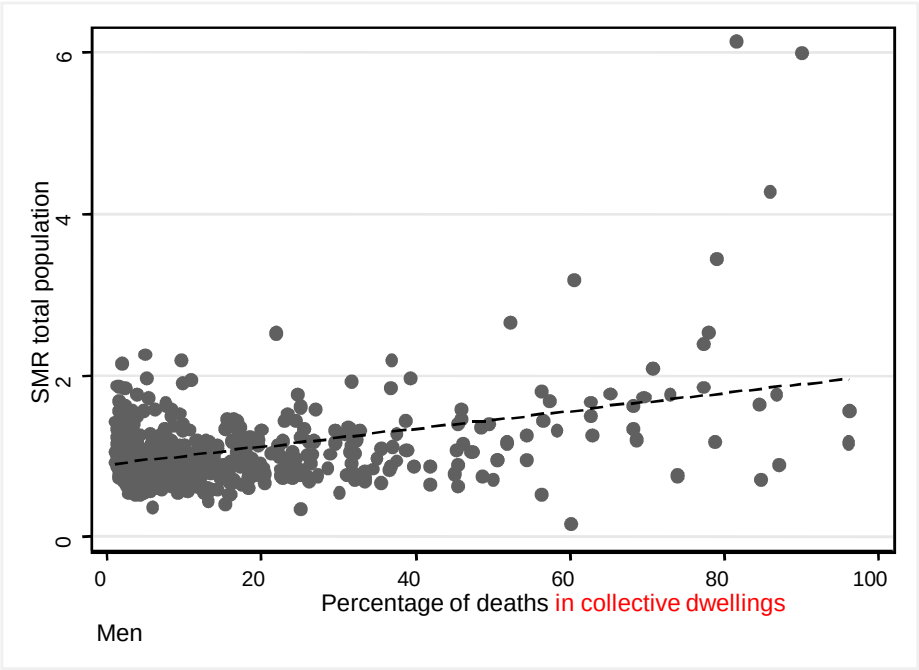
Figures

Figure 1 - Relationship between mortality in the total population and deaths in collective dwellings by census tracts: men and women. Region of Madrid, 1996-2003

Figure 2 - Relationship between mortality in the total population and the population excluding residents who died in collective dwellings, and the socioeconomic deprivation index by census tracts: men and women. Region of Madrid, 1996-2003



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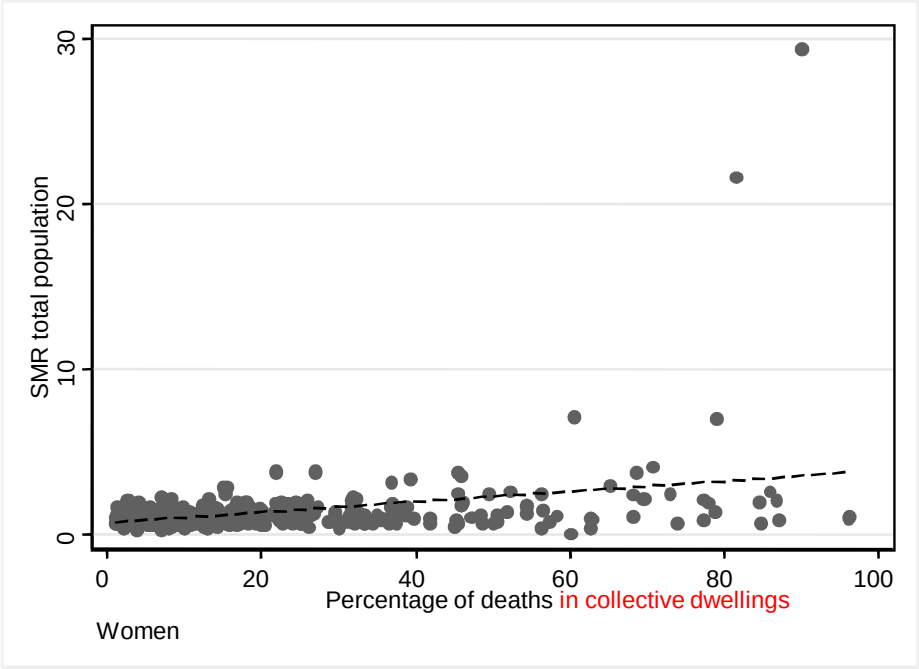

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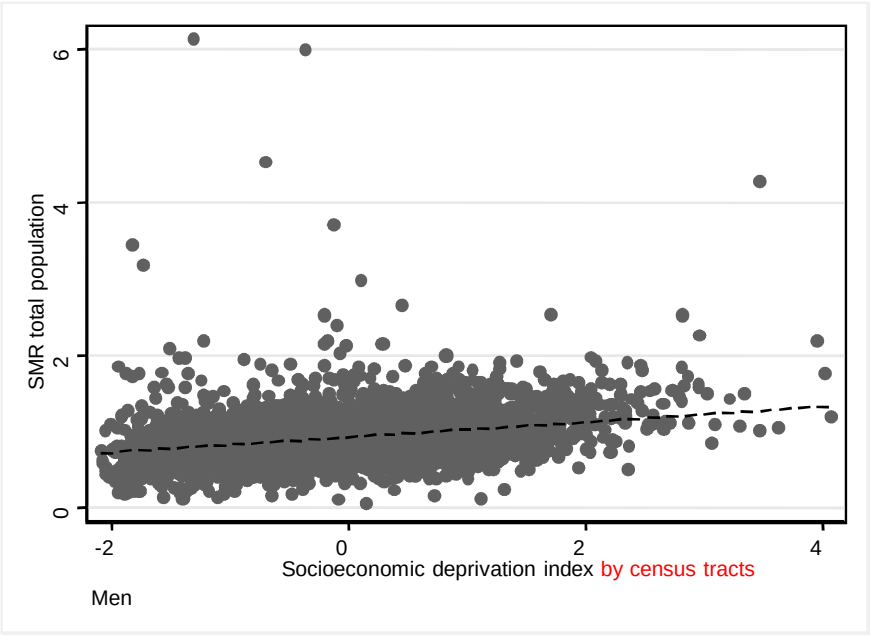

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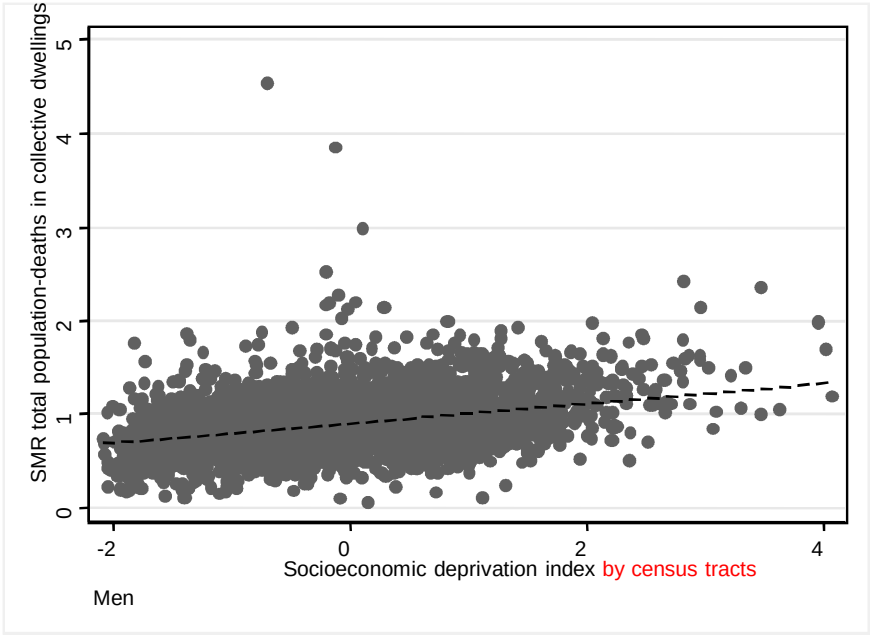

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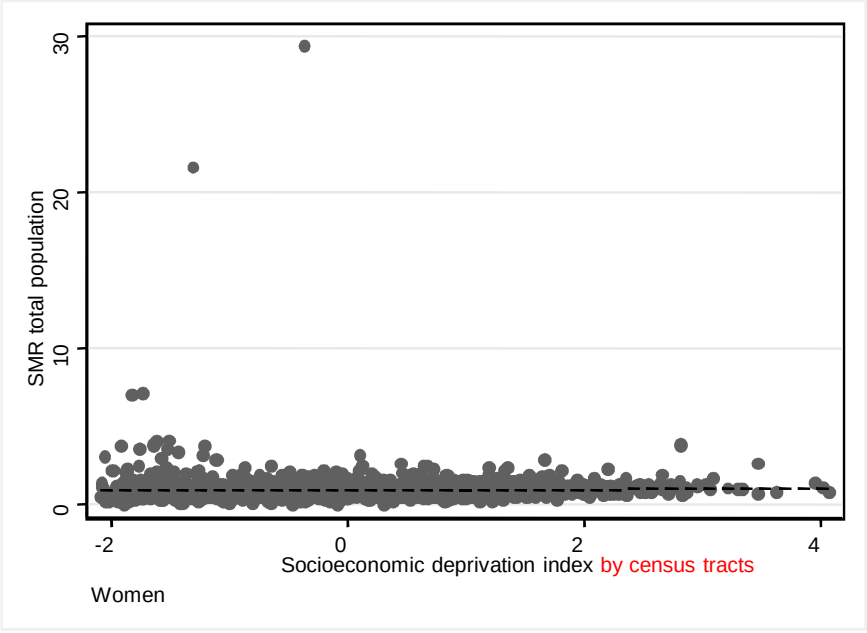

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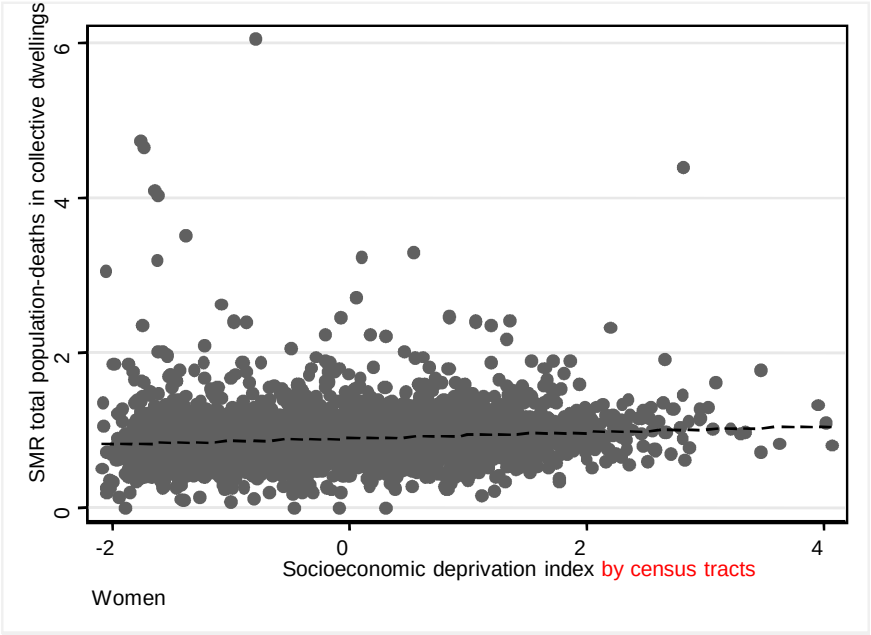

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