The effects of inequality in income distribution on health have been a topic of intense debate, in so far as researchers do not agree on how to interpret the results of studies or on which mechanisms are involved in creating these effects.1–5 Ecological studies, controlling for differences in average absolute income, have shown an association between income inequality and mortality within individual countries.6–11 Although this association has been attributed to a ‘statistical artefact’ (i.e. to the ecological fallacy resulting from drawing inferences at the individual level with group-level data)12,13 or to the confounding effect of race composition14 or education15 in most multilevel studies,16–24 though not all,25–27 have demonstrated an independent effect of income inequality on health even after adjusting with individual data.

One of the issues that needs to be clarified is whether the effect of income inequality on health is universal, in so far as a positive association was observed only in provinces with lower absolute income. Elderly persons living in Southern Italy represent the population subgroup most vulnerable to unequal income distribution. Income inequality can, in part, explain the historically higher mortality among women in Southern Italy compared to women in the North. These results indicate that income inequality affects the health of population subgroups differentially.

Keywords: income inequality, Gini coefficient, mortality

Thus, to better understand the association between income inequality and health, it has been proposed that research should move outside the North America31 to study contexts with high levels of income inequality.32

The objective of the present study was to examine the ecological relationship between income inequality and mortality in Italy, a country where income inequality is only slightly lower than that in the USA, and with marked, historically rooted, socio-economic and cultural geographical differences, the North being wealthier and more industrialised than the South.

Methods

Setting

For the present study, we considered the 95 provinces existing in Italy in 1994. In that year, Italy had a total population of 57 138 489 inhabitants; the provinces had a mean population of 601 458 inhabitants (range: 92 296 – 3 921 479). We grouped the provinces into four geographical areas: the North-east, the North-west, the Centre and the South plus the islands of Sicily and Sardinia.

Measures of income and income distribution

The data used to calculate the income indicators were the fiscal data on income earned in 1994 and declared in 1995 to the Tax Register of the Ministry of Finance. The data used refer to all types of taxpayers, including self-employed and retired persons. We identified a total of 26 534 490 fiscal households, composed of the declaring person and the fiscally dependent family members [including under-age children (< 18 years), children studying until 26 years of age, those permanently unable to work, and all relatives living in the same household with an annual income less than €2 840.50].

The disposable equivalised annual household income per capita was calculated by subtracting the net tax from the total

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income, and to take into account economies of scale it was adjusted for household size with the Italian equivalence scale. To measure income distribution at the province level, we used the Gini coefficient, a common index of income inequality. The Gini coefficient is derived from the Lorenz curve, which is a plot of the cumulative proportion of the population (households) against the cumulative proportion of total income. The coefficient is given by the area between the actual income distribution and the diagonal of equal incomes. The index ranges from 0 to 1, with higher values representing greater heterogeneity in income distribution. To calculate the Gini coefficient, we used the disposable equivalised annual household income. We also calculated at the province level the median disposable equivalised annual household income per capita, which was categorised into two levels (i.e. above or below the median) for modelling purposes. Accordingly, the provinces were classified into two groups (high or low median income).

Measures of mortality

We calculated the annual standardised mortality rate using mortality data from three consecutive years (1994–1996), to improve the stability of estimations; the data were obtained from the Italian National Institute for Statistics (ISTAT). For each province, we calculated both total mortality and the mortality by age-group (i.e. <1 year, 1–4 years, 5–24 years, 25–64 years and >64 years), for all causes and by gender. Mortality rates were directly standardised for age using the Italian population (1991 census) as standard; rates are expressed as the number of deaths per 1000 population.

Statistical analysis

Pearson correlation coefficients (r) were estimated to determine the correlation between standardised mortality rates, the Gini coefficient and the median income as continuous variables. The relationship between income inequality and total or age-specific mortality was modelled using multivariate weighted linear regression analysis. To address the interaction between income inequality and median income or geographical area, we constructed two separate models: in Model 1 we included the Gini coefficient, a median income dummy and the product term of the Gini coefficient and the income dummy; in Model 2 we included the Gini coefficient, geographical area dummies and the product terms of the Gini coefficient and area dummies. We also ran bivariate regressions stratifying by income level or geographical area to test the statistical significance of individual coefficients (results not shown). Mortality rates were weighted by the size of the denominators. There were no major violations of assumptions of linearity or normality. To establish the goodness of fit of the models, we calculated the percentage of total variance explained by the model (adjusted R²). Analyses were conducted separately for males and females, taking into account that the geographical distribution of mortality in Italy differs by gender. Analyses were conducted with SPSS version 8.0.

Results

Income indexes

The geographical distributions in quintiles of the median income and the Gini coefficient, by province, are shown in figures 1 and 2, respectively. The figures show a North–South gradient for the two income indicators, with lower median incomes and higher Gini coefficients in Southern Italy. The median income ranged from €4 559.80 in the provinces of Agrigento and Enna (Southern Italy) to €9 162.46 in the province of Milan (North-west Italy) (figure 1, table 1). The Gini coefficient varied from 0.312 in the province of Rovigo (North-east Italy) to 0.394 in the province of Palermo (Southern Italy) (figure 2, table 1).

Mortality

The geographical distributions of mortality rates for males and females (1994–1996), by province, are shown in figures 3 and 4, respectively. The geographical distribution of the mortality rates differed greatly by gender, with higher rates in Northern Italy for males and in Southern Italy for females. The national-level mortality rate was 11.4 per 1000 population for males and 6.6 per 1000 population for females (table 1). Total mortality at the province level ranged from 9.7 to 13.8 for males and from 5.8 to 8.3 for females (table 1).

Association between income inequality and mortality

We observed a significant positive correlation between the Gini coefficient and total mortality only among females (r = 0.44; P < 0.001) (table 2). The correlation between median income and mortality was positive for males (r = 0.33; P < 0.001) and negative for females (r = −0.39; P < 0.001).
When using the weighted regression to analyse the relationship between income inequality and mortality (table 3, Model 1), we observed a positive association between the Gini coefficient and total mortality in low-income provinces (reference level) for both males (B = 26.5; P < 0.001) and females (B = 30.5; P < 0.001). A negative interaction between the Gini coefficient and income level was observed for both males (B = −35.3; P < 0.001) and females (B = −30.4; P < 0.001); thus, in high-income provinces, the association disappears for both genders.

A positive association between income inequality and mortality was also found among males and females in the age-groups <1 year, 25–64 years and >64 years, yet only in low-income provinces; the association was particularly marked in the latter age-group, with a higher coefficient for women (B = 149.5; P < 0.001) as compared with men (B = 100.9; P < 0.05). Weak negative associations between the Gini coefficient and mortality were observed in the 5–24 age-group for both genders, as well as in males aged 25–64 years in high-income provinces.

When modelling the relationship accounting for geographical area (table 4, Model 2), a positive association between income inequality and total mortality was observed for both males (B = 45; P < 0.001) and females (B = 39.1; P < 0.001) living in Southern Italy (reference level). A significant positive association was present for both genders in Central Italy, although weaker with respect to the South; in fact, a negative interaction was observed for both males (B = −28.3, P < 0.05) and females (B = −30.8; P < 0.001). The association, although significant only for males in the age-group 5–24 years living in Southern Italy, was reversed for both genders in Northern areas, where the interaction terms were strongly negative.

Positive associations between the Gini coefficient and age-specific mortality were also found for both genders of all age-groups over 24 years in Southern and Central Italy. The strongest effect of income inequality was observed for persons >64 years living in Southern Italy: for every percent increment of the Gini coefficient there were 211 and 204 excess deaths per 100,000, respectively, for men and women.

A negative association between the Gini coefficient and mortality was found for males >64 years living in North-west Italy.

Whenever an association between the Gini coefficient and the mortality rates was observed, a statistically significant interaction between the Gini coefficient and the median income or the geographical area was also found, with the exception of Model 1 for females aged <1 year (positive association) and for the age-group 5–24 years (negative associations).

**Discussion**

In Italy, the geographical trends in the median income per capita and in the inequality in income distribution follow opposite directions, with the South having a lower yet more concentrated income. In this context, we found a positive association between income inequality and total mortality in provinces with a low median income and in the Southern and Central areas of the country. The effect of income inequality on mortality was strong for elderly persons in Southern Italy and in low-income provinces, particularly for women. A direct association of income inequality was also found for infant mortality in

**Table 1** Descriptive statistics of age-standardised mortality rates (MR × 1000), the Gini coefficient, and disposable equivalised annual household median income per capita, by province; Italy, 1994

<table>
<thead>
<tr>
<th>Variables</th>
<th>Range</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR males</td>
<td>9.7–13.8</td>
<td>11.4</td>
<td>0.9</td>
</tr>
<tr>
<td>MR females</td>
<td>5.8–8.3</td>
<td>6.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Gini coefficient</td>
<td>0.312–0.394</td>
<td>0.347</td>
<td>0.019</td>
</tr>
<tr>
<td>Income (£)</td>
<td>4 559.80–9 162.46</td>
<td>6 711.94</td>
<td>1 295.68</td>
</tr>
</tbody>
</table>

SD, standard deviation.

**Table 2** Linear correlation between age-standardised mortality rates (MR × 1000), the Gini coefficient, and disposable equivalised annual household median income per capita, by province; Italy, 1994

<table>
<thead>
<tr>
<th>Variables</th>
<th>MR males</th>
<th>MR females</th>
<th>Income</th>
<th>Gini coefficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>MR males</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MR females</td>
<td>0.49*</td>
<td>1.00</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Income</td>
<td>0.39*</td>
<td>−0.39*</td>
<td>1.00</td>
<td></td>
</tr>
<tr>
<td>Gini coefficient</td>
<td>−0.19</td>
<td>0.44*</td>
<td>−0.68*</td>
<td>1.00</td>
</tr>
</tbody>
</table>

*P < 0.001.
low-income provinces. Moreover, in some instances, we observed inverse associations between income inequality and mortality: in the age-group 5–24 years, in the age-group 25–64 years for males in high-income provinces, and among elderly men in North-west Italy.

In contrast to studies conducted in North America, which considered absolute income as a confounder, in the multivariate analysis we found a significant interaction between level of income and income inequality, and we observed a direct effect of the latter on average health status. Our findings at the ecological level are analogous to those of a multilevel study conducted in the USA by Kahn et al., who analysed the effect of inequality by income group and observed a worse health status for women with lower income in the states with high income inequality, compared to low-income women in states with low-income inequality. They observed no effect of income inequality on the health of women with higher household income. Similarly, Lochner et al. showed an effect of income inequality on mortality only in near-poor Whites in the USA, particularly among females. Fiscella and Franks found no independent effect of income inequality on mortality, yet they failed to consider the interaction effect. Our results support Ellison's observation that when using population-level data to study the effects of income distribution, it is necessary to control for the interaction between income distribution and average income, since income inequality has a disproportionate impact on the average health status of the poorer populations.

According to Gravelle, the association between inequality and mortality in low-income areas can be explained, at least in part, by the fact that where income is unequally distributed there is a high incidence of absolute poverty, which directly affects mortality. In fact, in 1994, the percentage of Italian families living below the poverty line was 20.6% in the South, 6.8% in the Centre, 4.4% in the North and 10.2% for the entire country. However, the effect of income inequality on health cannot be entirely explained in terms of residual contextual effects after having accounted for individual income, given that it is typically a relational, social system variable that may constitute a genuine risk factor at the population level through different pathways.

It has also been argued that income inequality may influence the height, slope and/or curvilinearity of the relationship between individual income and health. Thus, although population-level studies are considered to be insufficient for exploring the relationship between income inequality and health, in that they cannot discriminate between the effects of household income or other individual variables and the effects of income distribution, the ecological approach cannot be overlooked even in times of prevailing social and epidemiological atomism. The practice of adjusting for household income to disentangle the effects of income inequality from those of individual income in multilevel studies has been defined by Diez-Roux et al. as ‘artificial’ since absolute and relative differences are inextricably linked.

Ecological variables, such as welfare policies, have been indicated as potential confounders in the relationship between income inequality and health. In Italy, there is a high degree of autonomy in the local welfare policies. Moreover, although the National Health Service theoretically guarantees universal coverage, the public–private mix in healthcare expenditure is markedly heterogeneous across the country. Considering that the level of development of the social infrastructure and the welfare policies reflect the level of income inequality, the effects of income inequality on health would be expected to be evident only where the social system is less protective (i.e. in Southern Italy) or on those population groups that are more in need of equitable health services, such as infants and the elderly. In this regard, our finding of an association of income inequality with infant mortality in low-income provinces confirms the results of studies where this relationship was substantiated.

Mortality in Italy is characterised by striking geographical differences between genders. The higher death rates for males in the more industrialised North, as compared with the South, have historically been due to cancer and cardiovascular diseases. Although these variations have progressively decreased in the past three decades for males, in a context of declining overall mortality, a reverse pattern persists in the South for women, who are disadvantaged with respect to
have played out over the lifecourse of different birth cohorts, as of health relevant resources and exposures, and how these links historical links between income inequality and the distribution the above-mentioned diseases among women in the South. cause-specific mortality (not reported in this paper) confirms a: Reference area: South. hampered by economic and cultural barriers. Our analysis of healthcare services, although access to these services may be Southern Italy is partly due to conditions such as cardiovascular have reported that the mortality excess among elderly women in older than 64 years, a segment of the population that in the by the finding that the association was strongest among females women in the North. This discrepancy has been jokingly ascribed to the detrimental effects of cooking, as opposed to by the fact that the South has a higher rate of unemployment and more under-age inhabitants. Hidden economy, which prevails in the South, may product a bias in the calculation of income indexes, but we inhabitants. Hidden economy, which prevails in the South, may women in the North. This discrepancy has been jokingly ascribed to the detrimental effects of cooking, as opposed to eating, the Mediterranean diet. Our results suggest that income inequality may be a determinant of the enduring mortality excess among women in the South. This hypothesis is supported by the finding that the association was strongest among females older than 64 years, a segment of the population that in the South has traditionally been underprivileged from both an educational and cultural point of view. This population subgroup appears to be the most vulnerable to the supposed health effects of income inequality. Furthermore, other studies have reported that the mortality excess among elderly women in Southern Italy is partly due to conditions such as cardiovascular diseases, diabetes and cirrhosis, which are preventable through healthcare services, although access to these services may be hampered by economic and cultural barriers. Our analysis of cause-specific mortality (not reported in this paper) confirms the existence of a positive association with income inequality for the above-mentioned diseases among women in the South.

In summary, our mixed results may reflect the 'current and historical links between income inequality and the distribution of health relevant resources and exposures, and how these links have played out over the life course of different birth cohorts,' as argued by Lynch et al.

In interpreting the results of our study, several limitations should be taken into account. Firstly, the fiscal data used to calculate the income indicators may be biased by fiscal evasion and elusion. To assess this bias, we compared the official population by province with the Tax Register population (56.3 million inhabitants versus 43.2 million taxpayers, respectively). The difference was much higher in the South, ranging from 32 to 46%, compared with 12−22% in the Northern provinces. However, this difference is in part explained by the fact that the South has a higher rate of unemployment and more under-age inhabitants. Hidden economy, which prevails in the South, may produce a bias in the calculation of income indexes, but we cannot assess the extent of this bias or the direction in terms of the Gini coefficient. Nonetheless, the disposable income estimated in our study is almost identical to that calculated in a 1994 survey on household consumption conducted by ISTAT (r = 0.98; P < 0.001), supporting the reliability of our results.

Another source of potential bias may derive from our use of fiscal households as opposed to households registered by censuses. Had we considered census households, the economy of scale would have been considered to a greater extent, especially in the North, where the difference between the number of fiscal and census households was greater, due to lower unemployment. The bias would thus consist of a greater understimation of income in the North. However, since the potential bias produced by tax evasion and that produced by differences in the number of households may in part balance each other out, we did not adjust with any correction factors, in order to avoid introducing further distortions.

### Table 4 Weighted regression between income inequality and mortality including geographical area (Model 2)

<table>
<thead>
<tr>
<th>Age</th>
<th>All ages</th>
<th>&lt;1 year</th>
<th>1–4 years</th>
<th>5–24 years</th>
<th>25–64 years</th>
<th>&gt;64 years</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>B</td>
<td>SE</td>
<td>B</td>
<td>SE</td>
<td>B</td>
<td>SE</td>
</tr>
<tr>
<td><strong>Males</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>−5.1</td>
<td>3.9</td>
<td>−3.7</td>
<td>7.2</td>
<td>0.2</td>
<td>0.6</td>
</tr>
<tr>
<td>Gini index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North-east</td>
<td>12.8**</td>
<td>4.6</td>
<td>19.9**</td>
<td>8.9</td>
<td>0.1</td>
<td>0.8</td>
</tr>
<tr>
<td>North-west</td>
<td>16.6**</td>
<td>6.0</td>
<td>23.4</td>
<td>11.9</td>
<td>0.2</td>
<td>1.1</td>
</tr>
<tr>
<td>Centre × Gini</td>
<td>−28.3**</td>
<td>12.7</td>
<td>−58.9**</td>
<td>24.3</td>
<td>0.4</td>
<td>2.1</td>
</tr>
<tr>
<td>North-west × Gini</td>
<td>−55.1**</td>
<td>17.9</td>
<td>−15.1</td>
<td>35.2</td>
<td>3.6</td>
<td>2.2</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.34</td>
<td>0.48</td>
<td>0.04</td>
<td>0.29</td>
<td>0.37</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>Females</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>−7.2</td>
<td>2.0</td>
<td>8.3</td>
<td>7.3</td>
<td>−0.6</td>
<td>0.6</td>
</tr>
<tr>
<td>Gini index</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>North-east</td>
<td>16.1**</td>
<td>3.9</td>
<td>10.4</td>
<td>31.0</td>
<td>0.1</td>
<td>1.7</td>
</tr>
<tr>
<td>North-west</td>
<td>16.6**</td>
<td>3.1</td>
<td>−0.3</td>
<td>12.1</td>
<td>0.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Centre × Gini</td>
<td>−30.8**</td>
<td>6.6</td>
<td>−2.1</td>
<td>24.8</td>
<td>−4.0</td>
<td>2.2</td>
</tr>
<tr>
<td>North-east × Gini</td>
<td>−17.2**</td>
<td>9.0</td>
<td>−9.1</td>
<td>34.1</td>
<td>0.3</td>
<td>3.2</td>
</tr>
<tr>
<td>Adjusted R²</td>
<td>0.66</td>
<td>0.24</td>
<td>0.01</td>
<td>0.35</td>
<td>0.37</td>
<td>0.67</td>
</tr>
</tbody>
</table>

a: Reference area: South. SE, standard error.

*P < 0.05. **P < 0.001.
Finally, since we adopted a cross-sectional ecological study design, we limited the scope of the study to describe the relationship between income inequality and mortality. Multi-level studies would need to be conducted to assess the role of individual income and other ecological variables in generating the observable effect in ecological studies.

Our results emphasise the importance of taking into account the interaction between income level and income inequality. Moreover, they highlight the geography of health inequality in Italy, with a disadvantaged South. Accordingly, our findings may contribute to the current debate on the equalising policies that may be included as part of the devolution process in Italy.

Acknowledgement

The authors wish to thank Mark Kanieff and Alessia Tiberio for linguistic revision and editorial assistance.

Key points

- This ecological study is one of the first carried out on the entire population of an European country concerning the controversial relationship between income inequality and mortality.
- In Italy, income inequality is directly associated with mortality in low-income provinces and in the southern and central areas of the country. The association is marked for the elderly, particularly women.
- The mixed and not universal relationship of income inequality and health highlights the importance of taking into account the interactions between income inequality and income level in this type of studies.
- Income inequality can, in part, explain the historically higher mortality among women in southern Italy compared to women in the north.
- In the context of the socio-economic and health inequalities existing in Italy, with the south being underprivileged, results may suggest the need of equalising policies to be adopted to alleviate the gaps.

References


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