Small-Area Mortality in Italy between 2002 and 2018

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Italy is geographically heterogeneous, and there is a general feeling that certain areas (small villages, especially those in the south, or in inner, scarcely connected, and relatively deprived areas) are lagging behind in several respects, including mortality. This is however difficult to ascertain at small scale, i.e. municipalities, of which Italy has some 8,000, with an average population of about 7,500 residents, but large variability (from 30 to 2.6 million). Due to mergers and splits, the exact number of these municipalities changes almost every year, but for the period 2002-2018, Istat (the Italian national institute of statistics) developed a database that refers to a fixed number of them, with unvarying boundaries (those of 2018). Of these municipalities, therefore, and for every year of the interval, we know the sex and age structure of the population, and the number of deaths (by sex, not by age). Besides, Istat also elaborated a small set of ecological variables that characterize these municipalities as of 2018: altitude, accessibility, etc. (Table 1).

Table 1 Sources used for this study

Nick	Level	Full name	Link
Deaths	Mun	Population balance estimates 2001–2018; Demographic balance years estimates 2001–2018 (intercensal reconstruction)	(a)
Population	Mun	Population estimates 2002-2019 by age and sex at Jan 1st (intercensal reconstruction)	(b)
Life tables	Prov	Life tables	(c)
Indicators	Mun	- Main geographical statistics on municipalities and Statistical classifications and size of municipalities as of 12/31/2019 - Composite fragility index (CFI) and its components	(d) (e)

Notes. All official (Istat) data. Level (smallest available). Mun=Municipalities; Prov=Provinces.
(a) https://demo.istat.it/app/?i=RBD&l=it; (b) https://demo.istat.it/app/?i=RIC&a=2002&l=en; (c) https://demo.istat.it/app/?i=TVM&l=it; (d) https://www.istat.it/it/archivio/156224; (e) https://www.istat.it/it/archivio/292468.
Deaths: data detailed by sex, municipality, nationality and year (we used the years 2002–2018). Population: data detailed by age (single year, up to "100 and over"), sex, municipality, nationality, and year (we used the years 2002–2018). Life tables: data detailed by age (single year), sex, province and year. In this case we used the m_x series (age specific mortality rates) for year 2018 (Italy, both sexes) to derive our *E* series (expected deaths; see text), and the entire set (by province, 2002–2018) to test the performance of our indicators, *SMR*, comparing them with official mortality data (e_0).

Sex-specific crude death rates can be calculated at municipality level, but they are not very informative, as they largely depend on on the age structure of the local populations, and the share of municipality residents aged 70 years and over ranged between 5% and 63% in those years. In all cases, even if more detailed info were available (e.g. deaths by age), the small number of observations in several of these communes (about of fourth of which have less than 1,000 residents) discourages the estimation of small-scale life tables (despite some ingenious attempts at circumventing this type of difficulties; e.g. Anson 2018).

The lack of reliable small scale measures of mortality is particularly unfortunate, as the period was characterized by a marked tendency towards "regionalization" of the health system: each of the 20 administrative Italian regions has progressively been given more decision and managerial power in this field, which, according to several observers, caused a "drift" in the provision of health services, with some regions performing progressively better and others progressively worse. Allegedly, this has caused a resurgence of the internal heterogeneity in health services and outcomes that the reform of 1978 (with the creations of the National Health Systems) intended to contrast, with some initial success. The topic is extremely sensitive, in Italy, and it seems worth investigating, despite technical difficulties.

Standardized mortality ratios (SMRs)

To progress in this field, standardized mortality ratios, or *SMRs*, can be calculated (e.g. Anson 2018, Sánchez et al. 2020), breaking them down, if necessary, by geographical level g, sex s and year t. *SMRs* are obtained as the ratio between observed (D) and expected deaths (E), which in turn derive from the product of the resident (*de iure*) population P_{gstx} (x=age) and a vector of standard mortality rates m_x

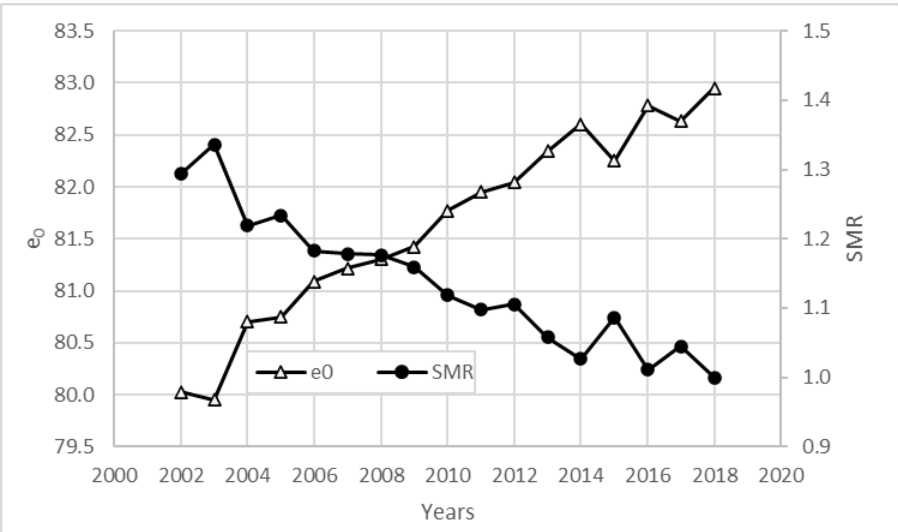
1) $$E_{gst} = \Sigma_x P_{gstx} \cdot m_x$$

Results depend on the standard, of course, but with a reasonable one (in our case, the 2018 Italian mortality rates), and under not-too-restrictive assumptions, the resulting measures

2) $$SMR_{gst} = D_{gst} / E_{gst}$$

provide a good and relatively unbiased estimate of mortality at local scale (despite the reservation of a few scholars, e.g. Roessler, Schmitt, and Schoffer 2021). Indeed, the measure passes a number of "quality checks" and correlates very strongly with life expectancy (Figure 1).

Figure 1 - Life expectancy at birth e_0 and standardized mortality ratio SMR, Italy 2002-2018



Note: R-square between e_0 and *SMR* ranges between 99% (national level) and 91% (provincial level - 107 units, each observed over 17 years). Source: Own calculations on Istat data (see Table 1).

While 2018 is our "pivotal year" (the one to which a few of the databases we use are anchored), in some cases, and especially in the study of the evolution of variability, it is preferable to use *scaled* standardized mortality ratios, *SSMRs*: these are the same as the *SMRs*, except that their yearly average, instead of declining (from about 1.3 in 2002 to 1 in 2018), is forced to 1 in all the years of the interval. In other words, what emerges in this case is the survival condition of each municipality relative to the national standard *in that year*.

Although unbiased (if certain basic conditions are met), the *SMR* indicator is subject to a natural random variability, which can be high for small communities, because in that case the denominator can be low (less than 5 in some 2,000 municipalities, each year). This is something that must be taken into account in interpreting the results.

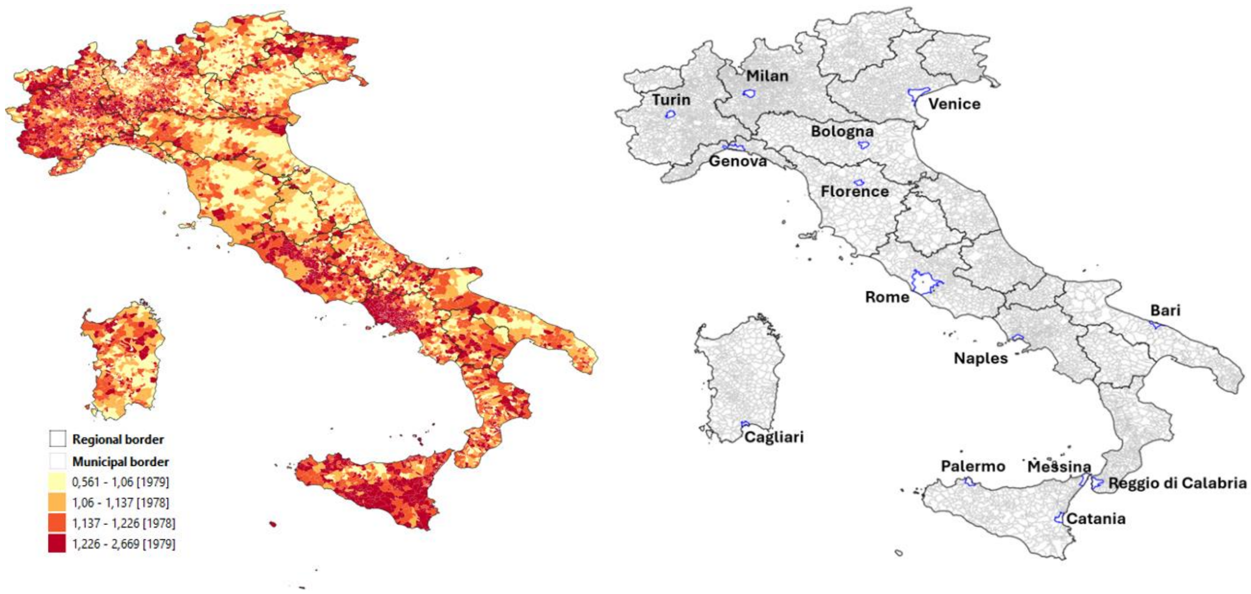
Our main research questions, all referred to Italy in the years 2002-2018, are the following:

1) How large was variability (meaning, inequality) in survival at municipal level?
2) How did variability (inequality) evolve over time?
3) Can any sign of a regional drift in survival be detected?
4) What were the main causes of "backwardness", or, more modestly, the contextual variables that best correlate with the poor survival performance of certain municipalities?

Heterogeneity in small-scale mortality in Italy

As for the first three research questions, the answer is provided in Figures 2 (map) and 3.

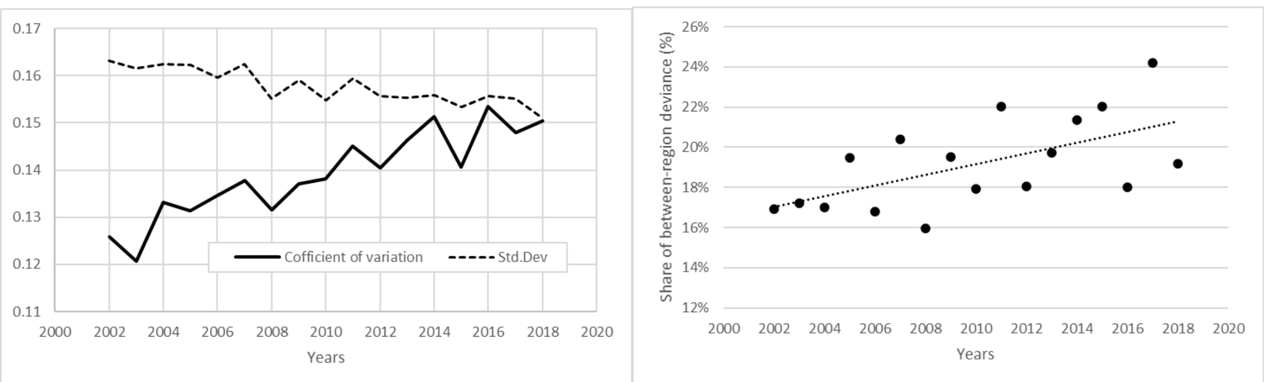
Figure 2 - Map of municipalities by mortality level (Italy, SMR average in 2002-2018, both sexes)



Note: *SMR* averages 1 in 2018, but is higher, on average, in the period 2002-2018 (see e.g. Figure 1)
Source: Own calculations on Istat data (see Table 1).

Figure 3 - Evolution of survival heterogeneity in Italy 2002-2018, both sexes combined (SMR measured at municipality level, on 7,912 such units. Weighted values)

a. Std.Dev and Coeff. of Variation *b. Between-region component of the total deviance*



Source: Own calculations on Istat data (see Table 2.1).

The (weighted) coefficient of variation was low, but on the increase, from about 12% to about 15% (panel *a*). Besides, some indications of a possible regional drift in survival can be detected: while relatively small, the between-region component of mortality variability increased in the period, from about 17% to about 21% in 17 years (panel *b*).

Covariates of small-scale mortality

With regard to the fourth research question (causes), a special fragility index prepared by Istat (aimed at summarizing the possible weak points of each municipality, such as lack of basic services, poor connectivity, unemployment, etc.) correlates very closely with the *SMR*, with the expected sign and in a statistically significant way. Large cities are subject to comparatively higher mortality risks, and so are municipalities located in the mountains and with a large share of older residents. Even a simple OLS model can explain a relatively large share of the variability of a properly adjusted *SMR* (were *E*-linked variability is kept under control), about 60%. However, spatial regressions are needed to keep spillover and omitted-variable effects (at least partly) into account.

Spatial regressions can be of two types, and we performed both: SAR (spatial lag component: the value of the dependent variable in one municipality affects that of neighbouring areas) and SEM (spatial error term: regression errors tend to cluster in specific ways, indicating that some unobserved variable affects the outcome of an entire cluster of communes). Results (not shown here) indicate that both phenomena (spillover and omitted-variable effects) play a strong role in the distribution of *SMR*, but become much less of a problem when duly taken into account. In all cases, while the distribution of residuals improves strongly with more refined analyses, the value and the significant of regression coefficients change only marginally.

Conclusions

Territorial heterogeneity in mortality was relatively small in Italy even though slightly on the increase in the years 2002-2018. A tendency towards regionalization was visible: higher between-region heterogeneity emerged during those years, although this component remains relatively (explaining about 20% of the total variance, on average)

As for the “causes” of higher or lower mortality al small-scale level, the main result is not surprising: communal “fragility” (a composite index prepared by Istat, and summarizing various possible facets of relative deprivation, such as lack of schools, hospitals, railroads, and other basic services) plays an important role. Both large cities and “isolated” municipalities (in the mountains, and with a large share of older population) suffer from relatively high mortality. Spatial lag components and unobserved variables seem to play an important role, but this topic needs to be further investigated.

References

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