

Small-scale mortality in Italy: 2002-2018*

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The study of small-scale mortality, although of great interest, is rarely feasible due to data limitations. By exploiting a municipality-level database prepared by the Italian National Institute of Statistics (Istat), and applying a standardisation technique to address the issues caused by data sparsity, Gustavo De Santis, Federico Benassi, Gianni Carboni, and Mauro Maltagliati present an original analysis of mortality in Italy at the municipal level for the years 2002-2018.

Life tables are the most precise instruments available to demographers for assessing overall mortality levels and trends in a population. Unfortunately, their construction is data-demanding: for both genders, and for each age x (from 0 to over 100), death risks (or rates) must be calculated. This requires a numerator (deaths) and a denominator (population), and results in more than 200 cells. If the observed population is small, random effects can easily predominate in one or more of these cells, producing unpredictable (and unreliable) results – even setting aside omissions, age misclassifications, and other forms of error. To be sure, a variety of methods exist to limit these distortions, but even they have their limits and can be stretched only so far. Is any analysis possible beyond that point?

Data, method and purpose

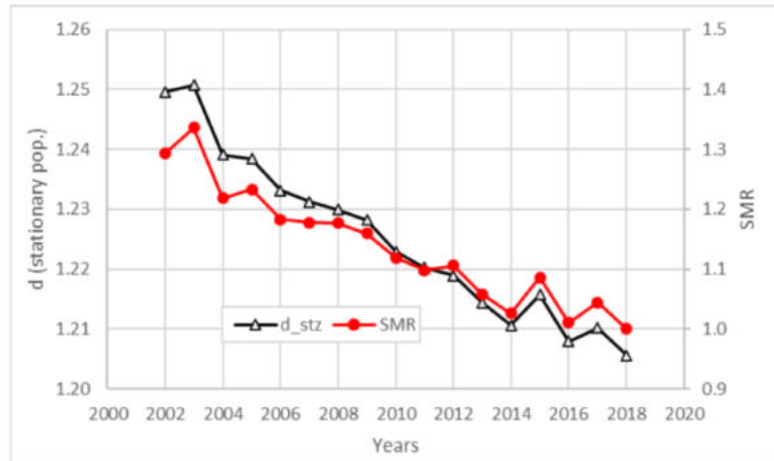
This question arose in our case. Exploiting an existing Istat database at municipal level (with a reconstruction of the series ensuring constant boundaries from 2002 to 2018 – a rare case indeed), we aimed to study small-scale mortality over the period across Italy's almost 8,000 local administrative units (LAUs), some of them very small (down to 30 residents in the worst case). For that purpose, we needed a reliable and comparable measure of mortality, but also one that was not too demanding in terms of data input.

We therefore opted for the standardised mortality ratio (SMR), which is simply the ratio between observed and expected deaths. The former were available, thanks to the aforementioned Istat database, while the latter were calculated by applying a standard

(national) mortality schedule to the local populations, broken down by gender and age.

Our SMR passed several preliminary tests, performing more than satisfactorily at the national level (Figure 1), as well as at the regional and provincial levels (NUTS2 and NUTS3, respectively – not shown here). Encouraged by this, we decided to apply it to Italy's municipalities, the smallest possible territorial level (De Santis et al. 2025).

Figure 1. Inverse life expectancy (d_{stz} , left scale, %) and standardised mortality ratio (SMR) in Italy, 2002–2018



Note. In the period under examination, life expectancy (e_0) in Italy increased, albeit irregularly, from 80 to 83 years. $1/e_0$, or inverse life expectancy, of course declined: it is the death rate in the corresponding stationary population (d_{stz}). Our indicator, *SMR* (standardised mortality ratio) was expected to evolve in line with d_{stz} , and it did: the determination index (or R^2) between the two series is above 99%. (R^2 proved very high also at the regional and provincial level, about 96% and 92% respectively – not shown here). Istat: Italian National Institute of Statistics.

Source: Own calculations on Istat data; De Santis et al (2025).

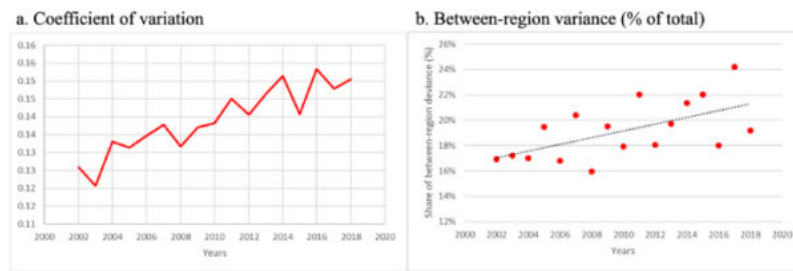
Our main curiosities (... oops, sorry. We meant: our main research questions) were:

- 1) How large were survival inequalities at the municipal level in Italy between 2002 and 2018?
- 2) How did these inequalities evolve over time?
- 3) Was any significant breakpoint detectable during this period?
- 4) Which contextual factors were most strongly associated with poor survival outcomes at the municipal level?

Main results

Figure 2 allows us to address our first three questions. Small-scale mortality variability was low in Italy during the period under examination (2002–2018): the coefficient of variation (i.e. the ratio between the standard deviation and the mean) ranged between 12% and 15% (panel a). On the negative side, it showed a slight upward trend, indicating somewhat greater relative heterogeneity (i.e. inequality) towards the end of the period.

Figure 2 - Evolution of survival heterogeneity in Italy 2002–2018, both genders combined (SMR measured at municipality level, across 7,912 such units, or LAUs)



Source: Own calculations on Istat data; De Santis et al (2025).

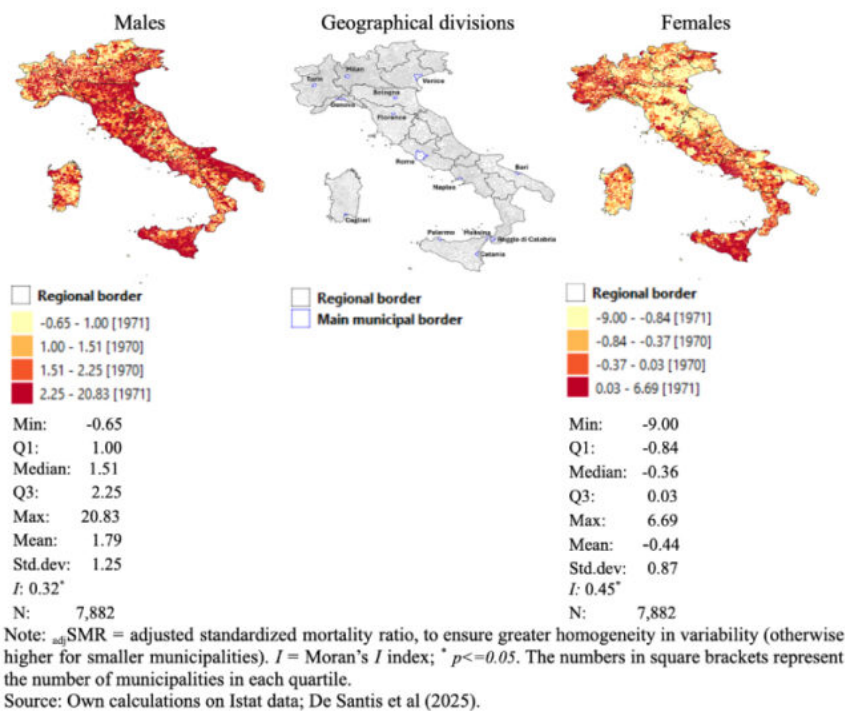
No major breakpoints emerged over the 17 years we examined. Panel b of Figure 2 indicates that, of the total variance in LAU mortality, around 80% was attributable to within-region differences, and only about 20% to between-region differences. In other words, the frequently voiced concerns about wider inter-regional disparities following the regionalisation of the Italian health system - initiated in 1992 - appear to have been overstated, at least in terms of mortality. (It should be noted, however, that mortality is not the only metric by which health system performance should be assessed, but in our case, no other measures were available.)

Here too, however, a note of caution is warranted: although modest (around 20%, as noted), the between-region component of variability showed an upward trend. In other words, regions were more diverse at the end of the period than they had been at the beginning. Unfortunately, with our data, it is not possible to determine how much of this trend is attributable to policy choices (i.e. regionalisation of the health system) and how much to other factors.

Maps and correlations

Figure 3 visualises the distribution of small-scale mortality, averaged over the period 2002–2018. As is often the case in such analyses, the researchers' hope of discerning a clear pattern is somewhat frustrated - particularly by the fact that male and female mortality do not appear to follow the same geographical distribution.

Figure 3 - Map of municipalities by mortality level (Italy, $_{adj}$ SMR average in 2002–2018, Males and Females)



Lower mortality, especially among females, is typically observed in eastern Italy (Trentino–Alto Adige, the southern part of Veneto, Emilia-Romagna, Marche), in the centre (Umbria and Tuscany), and in southern Sardinia. Conversely, poorer survival conditions are found in south-western Italy (particularly the area around Naples and in Sicily), in the municipalities surrounding the capital city Rome (though not in Rome itself), and – somewhat unexpectedly – in numerous municipalities in the “affluent” North-West (Liguria, Valle d’Aosta, Piedmont, and parts of Lombardy), as well as in several municipalities along the river Po (running eastwards from Turin to just below Venice). Another area of concern can be identified in the north-east, covering parts of Friuli–Venezia Giulia and the northern municipalities of Veneto.

Regression results clearly indicate that mortality during the period was higher in municipalities characterised by greater “fragility” (an ad hoc index developed by Istat) and lower affluence (Table 1). They also show clear evidence of spillover effects between adjacent municipalities: mortality is geographically correlated (as captured by SAR models – neighbouring municipalities tend to exhibit similar levels), and so are the residuals (SEM models), suggesting that unobserved factors (e.g. air pollution, local policies, etc.) influence areas that extend beyond individual municipal boundaries.

Table 1 Regression results (dependent variable: adj SMR , municipal mortality, Italy, 2002-2018)

	OLS		SAR		SEM	
	Females	Males	Females	Males	Females	Males
Rho/Lambda	-	-	0.4723 ***	0.0940 ***	0.5220 ***	0.3596 ***
Fragility	0.1919 ***	0.1828 ***	0.0737 ***	0.1601 ***	0.0239	0.1357 ***
Income2018pc	-0.1946 ***	-0.0649 ***	-0.1122 ***	-0.0584 ***	-0.1915 ***	-0.0726 ***
Log population	-0.3373 ***	1.0752 ***	-0.2765 ***	1.0356 ***	-0.3303 ***	1.1489 ***
Altitude	-0.0159	0.0411 ***	-0.0292 ***	0.0544 ***	-0.0222 .	0.0797 ***
% 70+	-0.2049 ***	0.2602 ***	-0.1747 ***	0.2618 ***	-0.1905 ***	0.2762 ***
R2	0.2156	0.5614	0.3869	0.5662	0.4026	0.604
Log likelihood	-9163.6	-9692.4	-8365.3	-9655.9	-8307	-9386
Akaike info criterion	18339.3	19396.9	16744.5	19325.7	16625.9	18783.9
Schwarz criterion	18381.1	19438.7	16793.3	19374.5	16667.7	18825.8
Moran I on residuals	0.363	0.206	-0.015	0.139	-0.045	-0.027

Notes. N = 7,882 Italian municipalities. Multicollinearity condition number 3.7. p-value: ***=0.001; . = 0.1.
Source: Own calculations on Istat data; De Santis et al (2025).

Other potentially relevant variables – among the relatively few available in our database – did not yield consistent results. For instance, we expected mortality to be higher in municipalities with smaller and older populations, or those located in mountainous areas. This was not the case, or at least not consistently so: results varied by gender and proved difficult to interpret, at least for us.

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References

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