A REGIONAL PERSPECTIVE ON ITALIAN LIFE EXPECTANCY DECELERATION

Gianni Carboni

Abstract. Using ISTAT period life tables, we traced annual life expectancy at birth for Italy's macro-areas (NUTS1) and regions (NUTS2) from 1980 to 2019. An unconstrained segmented-regression search identified breakpoints clustered around 2008—the first full year of the nationwide spending freeze and the regional deficit-recovery plans—suggesting a near-simultaneous inflection across the country. Taking 2008 as a policy-salient breakpoint, we then fitted interrupted time-series models to each regional trajectory. Almost all regions showed a statistically significant post-2008 flattening for the pooled sexes, and significance held for both men and women in all but a handful of small, data-sparse territories. Where significant, the estimated slope implies regions lost 0.5–2.0 years of life expectancy progression over the ensuing decade. The slowdown was almost universally sharper for women than for men, with only three regions displaying no gender gap. The striking synchrony of the breakpoint—first across macro-areas, then across regions aligns with an exogenous, nation-wide period shock tied to the 2008 wave of health-care austerity.

1. Introduction

For more than a century, life expectancy[1] in the world's affluent nations has climbed almost without interruption, sustained first by steep declines in infant mortality and infectious disease and later by sustained gains in nutrition, living standards, and chronic-disease prevention and care (Riley, 2001; Cutler *et al*., 2006). Recently, however, that steady ascent has begun to slow down: across most OECD countries a clear slowdown has been evident since around 2011 (Raleigh, 2019). Outside the extraordinary shock of the COVID-19 pandemic, the modern longevity curve had previously dipped only in the wake of the two World Wars and the 1918 influenza pandemic (Dattani *et al*., 2023).

Much of the recent work on this slowdown has focused on national aggregates, tracing it to a dwindling pace of progress against cardiovascular disease and several

[1] Throughout the paper, we focus on period life expectancy at birth as a summary measure of mortality conditions. While life expectancy is sometimes loosely referred to as longevity in the broader literature, we use the two terms with care: life expectancy denotes the specific demographic indicator analysed here, whereas longevity is used only in a general descriptive sense.

major cancers (OECD/The King's Fund, 2020; Steel *et al*., 2025). At the same time, countervailing trends in upstream risks—rising exposure to high body-mass index, sub-optimal diet, physical inactivity and harmful alcohol use—along with a loss of momentum in controlling LDL-cholesterol and systolic blood pressure, have eroded the earlier gains won through falling smoking prevalence (Steel *et al*., 2025).

A parallel body of research stresses the role of broad social and macro-economic currents: widening socioeconomic mortality gaps, mounting pressures on health systems, and, above all, the fiscal *austerity* that followed the 2008 financial crisis seem to have each been implicated in the recent stagnation of longevity (McCartney *et al*., 2022).

Italy offers a particularly revealing setting for probing this "austerity hypothesis". Although service delivery is highly regionalised, the Italian National Health Service is financed largely through a central block grant (de Belvis *et al*., 2022); after 2008 that grant levelled off in real terms across every region, effectively freezing per-capita health expenditure (Ciocci & Spagnolo, 2020). Crucially, this spending freeze coincided with a steady rise in the share of older residents—an age group that drives much of the demand for medical care—so that the system's resource base remained flat (if not actually declining) while the clinical workload kept expanding (the population aged 65+ grew by about 17 percent between 2007 and 2019).

A further element underscores why 2008 stands out in the Italian health narrative. Starting from 2007, the central government activated a series of "recovery plans" (piani di rientro)—deficit-recovery plans that targeted regions whose health accounts had slipped deep into the red. The mechanism was straightforward but stern: regions signing a plan received advance transfers only if they met tight quarterly targets for payroll cuts, bed reductions, hospital mergers and higher co-payments; falling short of those targets triggered automatic claw-backs and even tighter oversight (Aimone Gigio *et al*., 2018). Because the plans were layered on top of the nationwide spending freeze, they delivered an extra dose of austerity to large portion of the Italian population, including such populous regions as Lazio, Campania and Sicily. Recent evidence confirms that the tightening was not cost-free: regions under a deficit-recovery plans experienced a measurable rise in avoidable mortality relative to those outside the scheme (Arcà *et al*., 2020). Moreover, health austerity appears to have affected not only absolute mortality levels but also the long-running process of regional convergence. Periods of major cost-containment coincide with stalls in the narrowing of Italian North–South survival gaps, suggesting that fiscally weaker territories bear a disproportionate share of the burden and fall further behind the country's more prosperous regions (Carboni *et al*., 2024; De Santis *et al*., forthcoming).

Strikingly, the national mortality slowdown begins in the same period these measures took effect. Using causal approach, Salinari *et al*. (2023) show that Italy forfeited about 30 percent of its life-expectancy progression starting from 2008—a loss that precedes the modal OECD deceleration by three years.

Taken together, these coincidences strengthen the case for an austerity hypothesis: the concurrence of the 2008 national health-expenditure cap, the simultaneous launch of deficit-recovery plans in several regions, and the first signs of both a country-wide slowdown in life-expectancy gains and a stall in regional convergence all within the same brief interval points to a common cause.

At the national level, several complementary interpretations have been proposed to explain the post-2008 slowdown in life expectancy gains, emphasizing the role of the Great Recession and changes in age- and cause-specific mortality patterns (e.g. Egidi & Demuru, 2018). While these contributions highlight important mechanisms operating at the aggregate level, the present study adopts a different perspective by focusing on the temporal synchronization and territorial pervasiveness of the slowdown, with the aim of assessing whether the observed deceleration reflects a shared period shock rather than heterogeneous regional dynamics.

The aim of this study is therefore straightforward: we look for statistical evidence that the slowdown's geography is consistent with this policy shock. Specifically, we ask whether the deceleration begins at roughly the same time across Italy's territories (signalling synchrony) and whether that timing aligns with the launch of health-care austerity measures (2008). A positive answer to both questions would lend support to the view that fiscal retrenchment set Italy's longevity onto a slower path.

2. Methodological strategy

We analyse annual life expectancy at birth (e_0) for each Italian macro-area (NUTS1) and for all regions (NUTS2), using the official period life tables produced by ISTAT (the Italian Statistical Institute). Italy's formal NUTS1 map consists of five units: North-West, North-East, Centre, South and Islands. In addition to these, we examine every meaningful combination of contiguous units, yielding seven macro-area series in total: North-West, North-East, their aggregate North, the Centre, the official pairing South & Islands, and its two constituents analysed separately (South and Islands). On the contrary, the NUTS2 layer covers 20 territorial units.

The ISTAT's life tables are built directly from the complete register of deaths and mid-year population counts and apply a uniform methodology across territories, ensuring strict comparability in both space and time. Moreover, e_0 gives a single, policy-salient indicator that summarises mortality at all ages while retaining the raw year-to-year variability, an important feature when we search for structural breaks in regional trends.

From these annual life tables, we extract the period 1980–2019, a window long enough to detect structural shifts yet narrow enough to capture the late-2000s slowdown while excluding the disruptive effects of the COVID-19 pandemic that begins in 2020.

Our empirical strategy proceeds in two stages.

The first stage applies segmented regression to each macro-area series, letting the algorithm search freely for structural breakpoints and date them. If the breakpoints that emerge are consistent with the 2008-austerity hypothesis, we treat 2008 as the policy-salient breakpoint for the second stage, fitting an interrupted time-series model to every NUTS2 regional series.

Let's look at these two stages in detail.

2.1. Stage one: Segmented regression

Segmented (or piece-wise) regression extends ordinary least squares by permitting the slope of a time trend to shift at one or more unknown calendar years (breakpoints). Instead of guessing those dates a priori, the algorithm searches iteratively for the hinge points that best partition the series into straight-line segments. In our setting the practical question is: *does a given macro-area display a particular year after which the long-running rise in life expectancy flattens (steepens) in a statistically detectable way*?

The procedure treats each segment as linear, an assumption well suited to life-expectancy trajectories. In high-income countries, in fact, e_0 has advanced with near-constant annual gains for decades, a regularity documented by Riley (2001) for national averages and by Oeppen and Vaupel (2002) for best-practice records, among others. Local linearity therefore provides a reasonable baseline against which to test for structural breaks in the life expectancy series.

For each fixed macro-area we then model the annual life expectancy (Y_t accounts for $e_{0,t}$, with $t = 1980, \ldots, 2019$), as

$$Y_t = \beta_0 + \beta_1 t + \beta_2 (t - \tau) I_{\{t>\tau\}} + \varepsilon_t, \qquad (1)$$

where $I_{\{t>\tau\}}$ is an indicator function that equals 1 after the breakpoint τ and 0 otherwise; β_0 is the intercept, β_1 is the pre-break slope, β_2 captures the change in slope after τ, and ε_t is an independent error term.

Since life expectancy at birth has marched upward for decades, a negative post-break change in slope ($\beta_2 < 0$) flattens that trajectory: e_0 is still rising, but more slowly, so improvements decelerate.[2] In contrast, a $\beta_2 > 0$ steepens the climb, indicating an acceleration in longevity gains.

Breakpoints and coefficients of model (1) are estimated with the iterative procedure proposed by Muggeo (2008)'s *segmented* R package, which also allows the computation of confidence intervals for τ.

Because the 1980–2019 trajectories may harbour more than one structural shift, we follow recent joinpoint applications to life-expectancy data (Minton *et al*., 2023; Zazueta-Borboa *et al*., 2024) and let the algorithm search for up to two breakpoints in each e_0 series. In some cases, a single hinge may be enough; when additional breaks emerge, we document them yet focus our interpretation on the most recent one, as that is most germane to the late-2000s slowdown under study.

2.2. Stage two: Basic interrupted time series

If Stage one identifies 2008 as lying within the plausible break window, Stage two tests whether that same year can account for the trend shift in every regional series. Here the question is: *Can a single calendar year (2008, where applicable) account for the trend change in every region (NUTS2) series?* In such case, this would mean that 2008 alters the life-expectancy slope in (almost) every region and then the slowdown must stem from a nation-wide period shock

Concretely, we run the same basic interrupted time-series model for each region, always imposing a single predetermined year as the breakpoint. Formally:

$$Y_t = \beta_0 + \beta_1 t + \beta_2 I_{\{t>\bar{t}\}} + \beta_3 t I_{\{t>\bar{t}\}} + \varepsilon_t. \tag{2}$$

Here β_1 captures the pre-break yearly change in e_0, β_2 measures any immediate jump (up or down) *exactly* at year $\bar{t}$ and, finally, β_3 quantifies how much the post-break slope differs from the pre-break slope.

The form of model (2) is deliberately more flexible than the segmented-regression model (1). Now we fix a single, ex-ante breakpoint for all regions. Allowing both a level change (β_2) and an independent slope change (β_3) ensures that any departure from the pre-$\bar{t}$ trend can be detected. If the austrity hypothesis holds, then we would have $\bar{t}$ = 2008.

At this stage our attention centres on the coefficient β_3. A statistically significant negative β_3 signals that the post-$\bar{t}$ slope has flattened relative to the pre-$\bar{t}$ trend,

[2] Note: Theoretically, if the absolute value of β_2 exceeds that of the pre-break slope β_1, the post-break slope (β_1 + β_2) becomes zero or negative. In that extreme case life expectancy would plateau or even decline, rather than merely rising more slowly. All this also applies in the opposite direction.

indicating a deceleration in life-expectancy gains; a significant positive value would imply the opposite. In this stage, we estimate the models separately for men and women to check whether the break affects both sexes in the same way.

3. Results

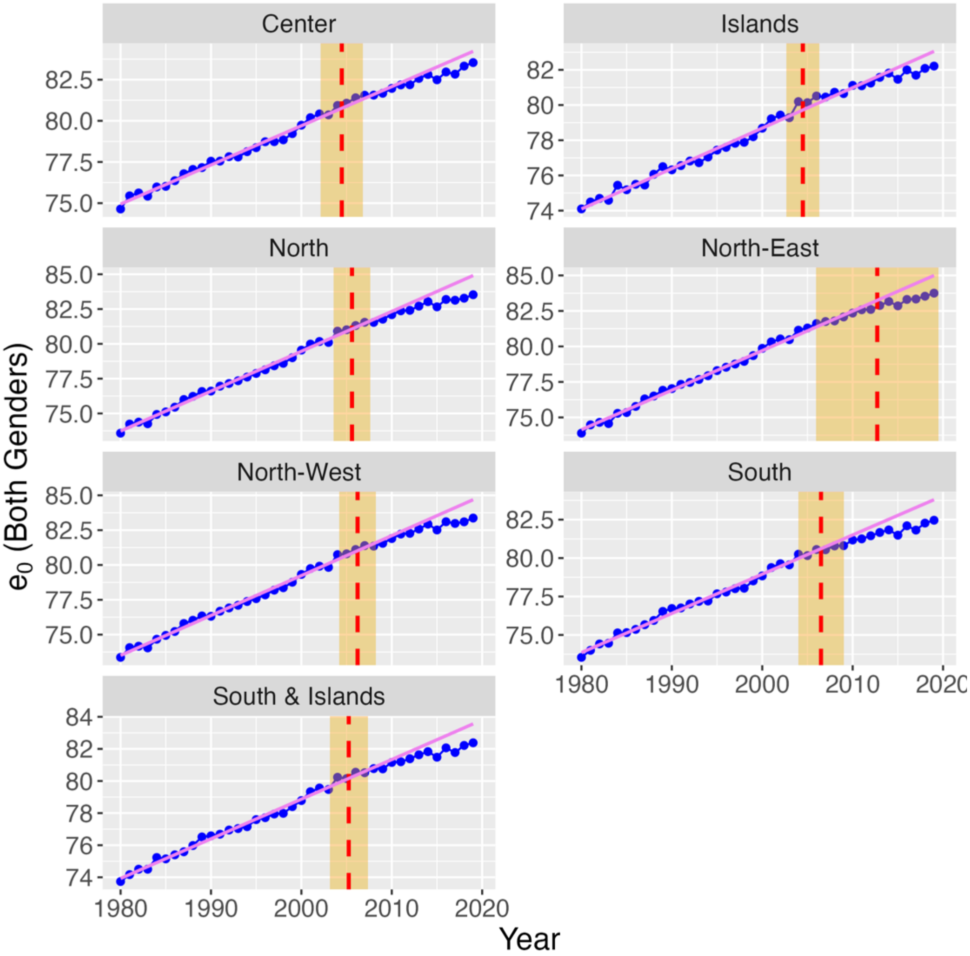
Figure 1 charts annual life expectancy at birth (e_0) for the seven macro-areas "combinations": blue points and lines show the observed series; the red dashed line marks the breakpoint estimated by the segmented-regression model, and the orange ribbon represents its 95% confidence interval. The purple line projects the pre-break slope beyond the breakpoint, illustrating how e_0 would have evolved had the earlier trend continued unchanged.

Several points are immediately apparent. Firstly, the direction of change is identical: in every panel the post-break slope lies below the projected purple line, signalling a deceleration in longevity gains. In other words, the rise in e_0 flattened simultaneously across the whole peninsula. Secondly, the breakpoints confidence bands overlap almost entirely, indicating that the North, Centre, and South & Islands all experienced an inflection in life-expectancy trends at virtually the same historical moment. Lastly, the 95% confidence bands in every macro-area stretch far enough to include 2008. This overlap means that choosing 2008 as the reference point does not contradict any of the segmented-regression results: it falls inside the statistical margin for basically every series. The lone outlier, a slightly later break in the North-East, likely reflects the noisier series of this relatively small macro-area and does not alter the overall pattern. We therefore carry 2008 forward into Stage two as the policy-salient breakpoint, confident that it is both empirically acceptable and substantively meaningful.

The next stage tests whether the 2008-same breakpoint can account for a significant slope change in each of the 20 NUTS2 regions.

Figure 2 shows the p-values for the post-2008 slope-change coefficient (β_3) from our interrupted time-series models (model 2), run separately for each of Italy's 20 NUTS2 regions and for females, males, and the combined population. Region codes appear on the horizontal axis, and the red dashed line marks the 0.05 significance threshold. We anchor the breakpoint to 2008 to test whether that single policy-inflection date coincides with a statistically detectable change in the life-expectancy trend everywhere in the country and in both sexes.

Figure 1 – *(Stage one) Breakpoints in Italian macro-area* e_0 *trends, Italy 1980 – 2019.*



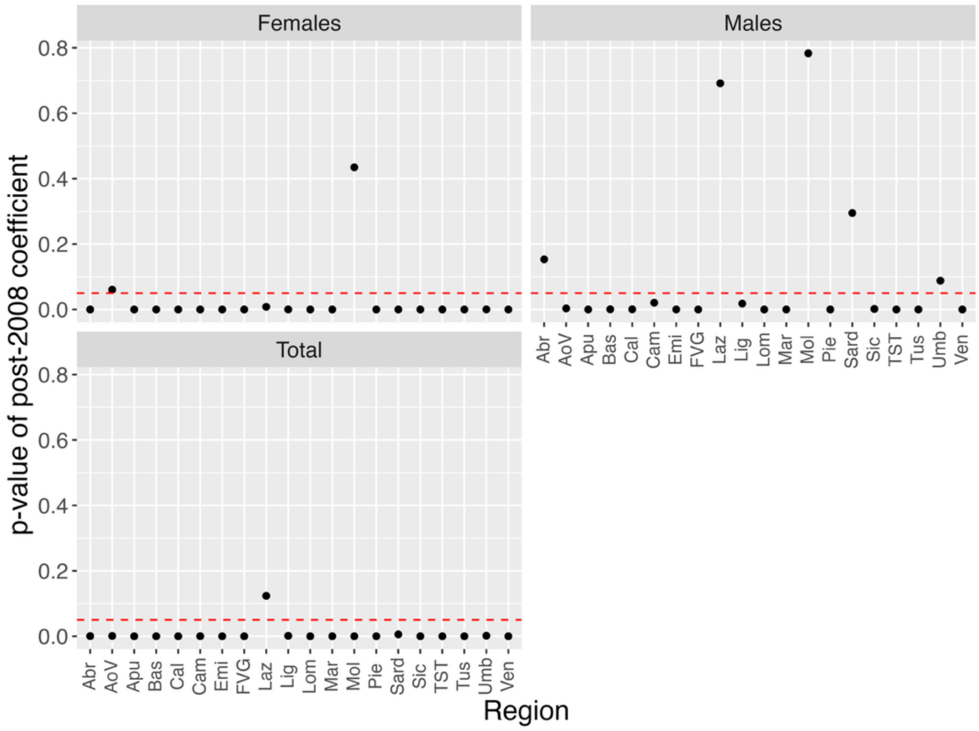
Blue lines show annual e_0 *for Italian macro-areas, 1980-2019. The red dashed line marks the breakpoint estimated by segmented regression; the orange rectangle is its 95% confidence interval. The purple line projects the pre-break trend beyond the breakpoint.*
Source: Our elaboration on ISTAT data.

Across the pooled-sex specification (bottom panel) almost nearly the whole country shows the same pattern: every region except Lazio posts a p-value below 0.05, indicating that 2008 coincides with a statistically significant shift in their life-expectancy trajectories. Splitting the analysis by sex refines the picture. In the female series Lazio becomes significant, and only the two least-populated regions (Aosta

Valley and Molise) fail to clear the 0.05 threshold. For males the result is reversed in Lazio (non-significant) and loses significance in four mid-small regions: Abruzzo, Molise, Sardinia, and Umbria. The handful of non-significant cases share two salient features: small population size and, most probably, higher year-to-year volatility. Exploring these local idiosyncrasies lies beyond our scope, yet the broad pattern is clear: with very few exceptions, regions register a synchronous deceleration after 2008. Where significant, the estimated β_3 values are uniformly negative, confirming that the post-2008 trend is flatter than the pre-break trajectory.

Beyond their statistical meaning, the patterns displayed in Figure 2 carry a clear substantive interpretation.

Figure 2 – *(Stage two) p-values for the post-2008 slope-change coefficient (β_3), by region and sex, Italy 1980–2019.*



Each dot reports the p-value for the post-2008 slope-change coefficient (β_3) from the basic interrupted time-series model with a common breakpoint fixed at 2008, shown separately by region and sex. The red dashed line indicates the 0.05 significance threshold. Region abbreviations: Piedmont (Pie), Aosta Valley (AoV), Liguria (Lig), Lombardy (Lom); Trentino-South Tyrol (TST), Veneto (Ven), Friuli-Venezia Giulia (FVG), Emilia-Romagna (Emi); Tuscany (Tus), Umbria (Umb), Marche (Mar), Lazio (Laz); Abruzzo (Abr), Molise (Mol), Campania (Cam), Apulia (Apu), Basilicata (Bas), Calabria (Cal); Sicily (Sic) and Sardinia (Sard).
Source: Our elaboration on ISTAT data.

The widespread significance of the post-2008 slope change indicates that the slowdown in life expectancy gains was not confined to specific regions or contexts, but instead emerged as a broadly shared national phenomenon. The fact that this result holds for almost all regions in the pooled-sex analysis, and for the vast majority when sexes are analysed separately, supports the interpretation of a common period shock rather than locally staggered dynamics.

In the pooled-sex series the β_3 coefficients span roughly -0.04 to -0.16 years per calendar year (median ≈ –0.12). That is to say, regions lost between about half a month and two months of annual e_0 improvement; over the decade this cumulates to 0.5–2 years of life expectancy that would have been realised had the earlier trend continued. In other terms, this pattern implies a contemporaneous and country-wide deceleration in mortality improvements, consistent with a nation-wide disruption rather than region-specific or cohort-driven processes.

Furthermore, this deceleration is geographically broad-based. Northern industrial regions such as Veneto (-0.15), Friuli-Venezia Giulia (-0.12) and Emilia-Romagna (-0.12) display magnitudes similar to those in many southern regions—e.g. Basilicata (-0.16) and Calabria (-0.12).

Lazio is the clear outlier: its pooled-sex coefficient (-0.04) is less than half the national median, mirroring the region's borderline significance in the Stage two "p-value test". Although Lazio faced one of the most stringent and prolonged deficit-recovery regimes (Aimone Gigio *et al*., 2018), its preservation of essential care standards, the potential buffering effect of high-profile facilities, and its greater fiscal capacity to cover lingering deficits likely cushioned the direct impact on life expectancy, helping to explain its comparatively muted post-2008 slowdown.

Concerning the gender gap of deceleration, in every region but one (Aosta Valley) the female post-2008 coefficient is more negative than the male counterpart, indicating a sharper deceleration in women's life-expectancy gains. Aosta Valley is the sole reversal, showing a steeper male slowdown, a result that likely reflects the volatility of a very small population base. Three northern regions (Friuli-Venezia Giulia, Trentino-South Tyrol and Lombardy) stand out for having virtually no gender gap: here the male and female coefficients are nearly identical, suggesting that whatever forces curbed longevity progress did so with equal intensity in both sexes.

Taken as a whole, the pattern points to a country-wide deceleration that began around 2008, lending strong support to the period-effect interpretation and leaving little room for staggered, cohort-specific dynamics (see conclusion).

4. Conclusion and discussion

This study asked whether the slowdown in Italian life-expectancy gains—widely noted in national analyses—also emerges when the country is viewed through its territorial mosaic.

We combined a segmented-regression scan across macro-areas with a region-by-region interrupted time-series test that fixed the breakpoint at 2008, the first full year of the spending freeze and the deficit-recovery plans. The two stages told a consistent story. Every macro-area exhibited a statistically indistinguishable hinge in the second half of the 2000s, and when 2008 was imposed on all 20 regions almost all registered a significant flattening of the e_0 slope. In short, the deceleration proves stubbornly synchronous—first across macro-areas and then, at finer resolution, across regions.

Such geographic concordance challenges any explanation that relies primarily on cohort dynamics. Each region has its own age structure, migration history and cohort composition, conditions that should yield locally staggered turning points if cohort effects were dominant. Yet the inflection arrives everywhere at practically the same calendar moment. The simpler reading is a period shock, and the timing singles out the 2008 wave of health-care austerity.

Why might mortality react so swiftly to fiscal restraint? Evidence from other high-income settings shows that the lag can be surprisingly short (McCartney *et al.*, 2022). Whether through longer waiting times, delayed adoption of new treatments, or stress on community-care networks, even seemingly modest cuts—or simply the failure to expand budgets in step with demand driven by an ageing population—rarely come without cost. Experience shows they can stall—even reverse—survival gains within just one planning cycle.

A limitation of this study considered on its own is that it relies on period life expectancy at birth as a summary indicator of mortality. As with any aggregate measure, life expectancy cannot capture heterogeneity by age, cause of death or population subgroups, and thus does not directly inform on the distributional mechanisms underlying the observed trends. This choice, however, is deliberate and closely aligned with the paper's objective, which is to identify the timing and geographic synchrony of structural breaks in mortality trajectories across Italian regions. In this respect, period life expectancy provides a stable, policy-relevant and fully comparable indicator over time and space, particularly well suited to detecting broad period shocks.

Importantly, ongoing and related work by the authors explicitly examines age-specific mortality patterns and cohort dynamics, with preliminary evidence suggesting that the post-2008 deceleration is difficult to reconcile with a purely cohort-based explanation and remains consistent with a dominant period effect linked to health-care austerity (Carboni *et al.*, forthcoming).

Most studies of the post-2008 slowdown have emphasised its cross-national synchrony. We show that the synchrony is resilient when the lens is narrowed to the regional level inside one country. Any convincing account of Europe’s longevity slowdown must therefore explain not only why many nations turned at once, but also why, within Italy, northern, central and southern regions did so together.

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References

AIMONE GIGIO L., ALAMPI D., CAMUSSI S.A., CIACCIO G., GUAITINI P., LOZZI M., … PAOLICELLI M. 2018. La Sanità in Italia: Il difficile equilibrio tra vincoli di bilancio e qualità dei servizi nelle regioni in piano di rientro, *Bank of Italy Occasional Paper*, No. 427.

ARCÀ E., PRINCIPE F., VAN DOORSLAER E. 2020. Death by Austerity? The Impact of Cost Containment on Avoidable Mortality in Italy, *Health Economics*, Vol. 29, No. 12, pp. 1500-1516.

CARBONI G., SALINARI G., DE SANTIS G., BENASSI F. 2024. Mortality Evolution in Italy: The End of Regional Convergence?, *Genus*, Vol. 80, No. 1, p. 28.

CIOCCI M., SPAGNOLO F. 2020. La spesa in Sanità: i dati CPT per un’analisi in serie storica a livello territoriale, Sistema Conti Pubblici Territoriali

CUTLER D., DEATON A., LLERAS-MUNEY A. 2006. The Determinants of Mortality, *Journal of Economic Perspectives*, Vol. 20, No. 3, pp. 97-120.

EGIDI V., DEMURU E. 2018. Impatto delle grandi crisi economiche su salute e mortalità: il caso italiano, La società italiana e le grandi crisi economiche 1929–2016, Istat, *Annali di Statistica*, pp. 57–82.

McCARTNEY G., McMASTER R., POPHAM F., DUNDAS R., WALSH D. 2022. Is Austerity a Cause of Slower Improvements in Mortality in High-Income Countries? A Panel Analysis, *Social Science & Medicine*, Vol. 313, pp. 115397.

MINTON J., HIAM L., McKEE M., DORLING D. 2023. Slowing Down or Returning to Normal? Life Expectancy Improvements in Britain Compared to Five

Large European Countries Before the COVID-19 Pandemic, *British Medical Bulletin*, Vol. 145, No. 1, pp. 6-16.

MUGGEO V.M. 2008. Segmented: An R Package to Fit Regression Models with Broken-Line Relationships, *R News*, Vol. 8, No. 1, pp. 20-25.

OECD, THE KING'S FUND. 2020. Is Cardiovascular Disease Slowing Improvements in Life Expectancy? OECD/The King’s Fund Workshop Proceedings, OECD Publishing, Paris

OEPPEN J., VAUPEL J.W. 2002. Broken Limits to Life Expectancy, *Science*, Vol. 296, No. 5570, pp. 1029-1031.

RALEIGH V.S. 2018. Stalling Life Expectancy in the UK, *BMJ*, Vol. 362, k4050.

RILEY J.C. 2001. *Rising Life Expectancy: A Global History*, Cambridge University Press, Cambridge.

SALINARI G., BENASSI F., CARBONI G. 2023. The Effect of the Great Recession on Italian Life Expectancy, *Population Research and Policy Review*, Vol. 42, No. 1, p. 3.

DATTANI S., RODÉS-GUIRAO L., RITCHIE H., ORTIZ-OSPINA E., ROSER M. 2023. Life Expectancy, *Our World in Data*.

DE SANTIS G., BENASSI F., CARBONI G., MALTAGLIATI M. Forthcoming. Local Mortality Patterns in Italy at the Beginning of the 21st Century, *Genus* (forthcoming)

STEEL N., BAUER-STAEB C.M.M., FORD J.A., ABBAFATI C., ABDALLA M.A., ABDELKADER A., … DEMETRIADES A.K. 2025. Changing Life Expectancy in European Countries 1990–2021: A Subanalysis of Causes and Risk Factors from the Global Burden of Disease Study 2021, *The Lancet Public Health*, Vol. 10, No. 3, pp. e172-e188.

ZAZUETA-BORBOA J.D., VAN HEMELRIJCK W.M., ZENGARINI N., SIZER A., KUNST A.E., MARTIKAINEN P., JANSSEN F. 2024. Long-Term Trends in Educational Inequalities in Alcohol-Attributable Mortality, and Their Impact on Trends in Educational Inequalities in Life Expectancy, *Frontiers in Public Health*, Vol. 12, Article 1355840.

Gianni CARBONI, University of Sassari, gcarboni3@uniss.it