Population health and the economy:

Mortality and the Great Recession in Europe

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Abstract

We analyze the evolution of mortality-based health indicators in 27 European countries before and after the start of the Great Recession. We find that in the countries where the crisis has been particularly severe, mortality reductions in 2007-2010 were considerably bigger than in 2004-2007. Panel models adjusted for space-invariant and time-invariant factors show that an increase of one percentage point in the national unemployment rate is associated with a reduction of 0.5% ($P < 0.001$) in the rate of age-adjusted mortality. The pattern of mortality oscillating procyclically is found for total and sex-specific mortality, cause-specific mortality due to major causes of death, and mortality for ages 30-44 and 75 and over, but not for ages 0-14. Suicides appear increasing when the economy decelerates—countercyclically—but the evidence is weak. Results are robust to using different weights in the regression, applying non-linear methods for detrending, expanding the sample, and using as business-cycle indicator GDP per capita or employment-to-population ratios rather than the unemployment rate. We conclude that in the European experience of the past twenty years recessions, on average, have beneficial short-term effects on mortality of the adult population.

KEYWORDS: Recessions; Great Recession; Europe; mortality rates; life expectancy at birth; population health.

1. Introduction

Political and economic upheavals experienced by European countries in the past three decades provide substantial material to investigate the influence of social and economic conditions on health. This article focuses on the Great Recession, a global economic and financial crisis (Kose and Terrones 2015) that was particularly severe in many European countries, where there were big increases in unemployment (Figure 1), as well as generalized banking problems, large public and private debts, and austerity policies that have created serious social distress and major financing problems for public services, including health care. Previously, in the early 1990s, the breakdown of the Soviet Union and the transition to a market economy in the former centrally planned economies of Eastern and Central Europe were the occasion for major downturns of population health—with large increases of mortality rates in all countries of the old Soviet bloc (Cornia and Paniccià 2000). Contrarily, in Western Europe the 1990s saw steady improvements of health conditions, as it is clearly illustrated by the evolution of life expectancy at birth (e_0 in demographic notation), life expectancy at 65 (e_{65}) and infant mortality rates (Figures 2 to 4). The 21st century started with a recession which was generally mild in most European countries, implying moderate increases in unemployment rates (Figure 1). The following economic expansion ended in late 2007, then economic conditions deteriorated rapidly with many European countries suffering a severe downturn of economic activity with soaring unemployment. Somewhat surprisingly, the health effects of the Great Recession in Europe have been controversial. Initial reports of harmful effects of the recession on health and health care in Europe in general or in specific European countries (Karanikolos et al. 2013; Kentikelenis et al. 2014; Simou and Koutsogeorgou 2014) were questioned (Liaropoulos 2012; Tapia Granados and Rodriguez 2015) and several authors have found that apparently the recession is having beneficial effects on health (de la Fuente et al. 2014), particularly on major indicators of population health, including general mortality (Toffolutti and Suhrcke 2014; Regidor et al. 2016). After 2010 the available data for both e_0 and e_{65} reveal continuous improvement—though Germany is an exception (Figures 2 and 3).

The unemployment rate has been often used as business cycle indicator in studies to ascertain the impact of the business cycle on mortality rates. Studies of different countries and periods have usually found that once long-term trends are adjusted for, general mortality and mortality due to major causes of death tend to decrease in recessions, that is when the unemployment rate is rising (e.g. Ogburn and Thomas 1922; Tapia Granados and Diez Roux 2009; Eyer 1977a; Ruhm 2000, 2007, 2015a, 2015b; Gerdtham and Ruhm 2006; Haaland and Telle 2015). On the other hand, in studies on individuals it has been often found that the risk of death differs between jobless individuals and employed ones (Kasl and Jones 2000), with unemployed having a higher risk of death compared to their employed counterparts (e.g. Sullivan and Wachter 2009; Burgard et al. 2009). These opposing effects of individual unemployment and contextual unemployment are not inconsistent, and have been observed to operate concurrently when individual-level data are linked to population-level data (Tapia Granados et al. 2014). Confusion has been often created by the fact that in some reviews of this kind of literature (e.g. Catalano et al. 2011), terms such as "economic decline" or "unemployment" have been used indistinctively and imprecisely to mean specific individuals suffering unemployment or individuals in populations exposed to a high unemployment rate.

A consensus seems to be emerging that, at the level of individuals, ill health and joblessness are likely to be linked by bidirectional causality. This implies that causality probably exists from joblessness to higher risk of disease and death, and in the opposite direction, from ill health to higher risk of becoming unemployed. Studies that have tried to disentangle these causal effects suggest that indeed unemployment raises the risk of disease or death in individuals who suffer it (Sullivan and Wachter 2009; Burgard, Brand, and House 2009; Tapia Granados et al. 2014), as well as ill health raises the probability of becoming unemployed (Valkonen and Martikainen 1996; Martikainen and Valkonen 1996). On the other hand, the pattern of mortality rising over trend in periods of prosperity and falling below trend in recessions, that is, oscillating procyclically, has been found in a variety of high-income market economies (Ogburn and Thomas 1922; Tapia Granados and Diez Roux 2009; Eyer 1977a; Ruhm 2000; Gerdtham and Ruhm

2006; Ruhm 2007; Haaland and Telle 2015; Sen 2001; Tapia Granados 2005, 2008, 2012; Tapia Granados and Ionides 2008, 2011; Neumayer 2004; Rolden et al. 2014; Lindo 2015) as well as some middle-income economies (Abdala et al. 2000; Gonzalez and Quast 2010a, 2010b; Lin 2009). In many of these studies in which total mortality and mortality due to major causes of death have been found to oscillate procyclically, a countercyclical oscillation has been found in suicide rates, which usually rise when the economy deteriorates.

In this paper we use a variety of mortality-based health indicators to describe the evolution of population health in Europe before and after the start of the Great Recession. A variety of methods are used to investigate the relation between economic conditions and changes in mortality-based indicators in the years after the turn of the century. We obtain consistent results across the general population, male and female subpopulations of males and females, and different age strata. Given the data used and the analysis we have done, we cannot compare across different socioeconomic groups, or to groups of employed or unemployed people.

2. Data

This investigation comprises the 27 European countries with population over a million. That includes 25 members of the European Union—all EU members except Luxemburg, Malta and Cyprus—plus Norway and Switzerland. Data come from three databases, the European Health for All Database (HFA-DB, WHO Regional Office for Europe 2016a), the European Health for All Mortality Database (HFA-MDB, WHO Regional Office for Europe 2016b) and the World Development Indicators (WDI, World Bank 2016).

Our investigation focuses mainly on life expectancy at birth, e_0, as the indicator that summarizes mortality at all ages and is increasingly utilized as the best comprehensive indicator of population health for inter-temporal and cross-national comparisons (Sen 2001; Riley 2001; Szreter and Mooney 1998). But for the sake of comprehensiveness, we examine a set of 15 indicators of population health. They include general and sex-specific e_0, e_{65}, infant mortality, and age-standardized death rates for all causes, for six major causes of death, and for ages 0-14, 30-44 and 75 and over. Cause-specific mortality rates

that we investigated include six major causes of death: cardiovascular disease (CVD) and a subset of it, ischemic heart disease (IHD), respiratory disease, transportation injuries, infectious and parasitic disease (I&PD), and suicide. We used the national unemployment rat—which is a lagged countercyclical indicator of the business cycle which rises some quarters after the recession has started— as main indicator of macroeconomic conditions. But we also used the employment-to-population ratio (EPR) and gross domestic product (GDP) per capita as explanatory variable indexing macroeconomic conditions. Appendix A includes all data used in the analysis and further details on data sources.

3. Methods

Data downloaded from the HFA-DB in March 2016 are relatively complete for health indicators up to 2013, but not for later years (Figures 1 to 3). For our descriptive analysis, we consider that 2007 was the last year of the expansion before the recession openly started in most European countries in 2008. Thus we compare the improvement in population health—as measured by the gain in e_0—in the 3-year period 2007-2010 (recession period) with the improvement in the previous three-year period 2004-2007 (pre-recession or expansion period) in the 26 countries of our general sample for which e_0 data are available for the years 2004, 2007, and 2010 (Table 1). Then we compare the evolution of the 16 indicators of population health in 2004-2007 and 2007-2010 in the 27 countries of our sample classified according to the severity of the crisis (Table 2).

Regression models are used to test whether the change in economic conditions is associated with changes in health indicators (Tables 3 and 4). For our regression analyses, which do not imply any assumption on the dating of the recession, we use the 27 countries during the period 2004-2010, and we check the robustness of the results to sample selection by expanding the panel to the whole decade since the start of the century, as well as to two longer periods: 2000-2013 and 1995-2013. We do not expand the panels further backward to the early 1990s to avoid including the years of transition to a market economy in the countries of Eastern Europe that were associated with major increases in mortality (Cornia and Paniccià 2000).

Significant correlations between time series with trends are usually meaningless in terms of causality (Diggle 1989; Gujarati 2003). Series need to be prewhitened to avoid spuriously significant results in statistical tests. Different methods can be used for prewhitening, the most common procedures imply just eliminating the trends, detrending the series.[1] We present here the results for panel regressions with fixed effects for countries and years and country-specific linear trends (Table 3), as well as results for models with non-linear detrending (Table 4, see also Appendix B for details). Nonlinear detrending analysis is arguably preferable (Ionides et al, 2013) but here we keep linear detrending as our primary analysis for the benefit of simplicity.

In our main regression models the dependent variable h_{tj} is a health indicator (or its natural logarithm) for year t and country j. The model equation is

$$h_{tj} = \alpha + \beta \cdot U_{tj} + \Pi_t + \Omega_j + \gamma_j \cdot t + \varepsilon_{tj} , \qquad [1]$$

where U_{tj} is the unemployment rate for country j in year t; Π_t and Ω_j are dummies for year and country, γ_j is the slope of a country-specific time trend, and ε_{tj} is the error term. Observations were weighted by the square root of the population weight to compensate for heteroskedasticity.

The fixed effects Π_t and Ω_j for year and country and the country-specific linear trends give some protection against biases linked to the influence of omitted variables, known as "confounders" in epidemiological terminology. While time fixed effects estimated by including a year dummy in the model adjust for space-invariant factors that differ across time (say mild temperatures in winter in all European countries during the Great

[1] Differencing is the simplest detrending method, and the one that was used in this investigation for some correlations. In our regression analysis, trends were taken care of by using panel analysis with (a) fixed effects for year and state; (b) fixed effects for year and state plus country-specific linear trends; (c) variables transformed by nonlinear detrending; and (d) variables in differences and fixed effects for years only. These are standard methods that have been previously used for similar purposes (Ruhm 2000; Gerdtham and Ruhm 2006; Neumayer 2004; Ionides et al. 2013). We obtained quite similar results using these four types of models.

Recession potentially causing lower rates of respiratory disease mortality), country fixed effects adjust for time-invariant factors that differ across countries (say higher alcohol consumption in some countries compared with others). Country-specific linear trends protect against the influence of potential confounders that change slowly and can be approximated with a linear trend (Ruhm 2000).

Variables related to economic activity, such as air pollution, are not appropriate as covariates in the regression model because they are conceivably the mechanisms for which unemployment fluctuations are a proxy. Including in the model two measurements of the same phenomenon, weak identifiability would be expected (Ionides et al. 2013). Our analysis investigates the evidence for the existence of cyclical mortality, which is prerequisite for further study of the mechanisms.

4. Descriptive Analysis

Unemployment rates rapidly increased in 2007-2010 (Table 1, Figure 1) but health indicators (Figure2 2 to 4) continued improving, with e_0 and e_{65} rising even faster in countries such as the Baltic states, Spain or Greece, strongly affected by the economic crisis (Figures 2 and 3). Considering the 26 countries for which e_0 data are available for 2004, 2007 and 2010, e_0 grew both in 2004-2007 and in 2007-2010, with the only exception of Lithuania and Latvia, where e_0 had decreased in the period 2004-2007 previous to the crisis (Figures 2 and 5, upper panel). In this period of declining e_0—which implies rising mortality—the economy of these two Baltic nations had had a boom, with GDP growth reaching phenomenal rates of 12.2% in Latvia in 2006 and 9.8% in Lithuania in 2007.

Both in 2004-2007 and 2007-2010 there is a positive and significant correlation between the change in unemployment, ΔU, and the change in life expectancy at birth, Δe_0. Considering the changes either in 2004-2007, or in 2007-2010 the Pearson correlations are respectively $r = 0.56$ ($P = 0.003$, Figure 5, upper panel), and $r = 0.83$ ($P < 0.0001$). When the correlations are computed weighting the observations by the square root of the population size, so that small countries do not have disproportionate influence, the correlations are reduced, but they are still highly significant (0.52, $P =$

0.006, for 2004-2007, and 0.74, $P < 0.0001$, for 2007-2010). The scatter plot of Δe_0 and ΔU in 2007-2010 (Figure 5, bottom panel) may suggest that the Baltic states, Spain, and Ireland are outliers with undue influence in the high value of the correlation. However, suppressing the Baltic states, Spain, and Ireland, $r = 0.58$ with the 22 unweighted observations and 0.59 when the observations are weighted by the square root of population (P=0.004 in both cases). These correlations are very supportive of the impression that, paradoxically, the more severe was the economic downturn the greater was the increase in e_0 and, therefore, the decrease in mortality rates.

Sorting the 27 countries by the severity of the recession in three groups (Table 2), the changes before and after 2007 show that mortality rates that had been falling in 2004-2007, continued falling in 2007-2010. However, in the countries where the crisis was most severe (Table 2, Panel C) there were greater improvements in population health during the three years of recession than in the three previous years of economic expansion. Between 2007 and 2010 general mortality decreased 4.3% in the countries with mild recession, 6.4% in the group of countries where the crisis was moderate, and 10.5% in the countries where the crisis was most severe (Table 2). This gradient of health improvement in 2007-2010 correlated with the severity of the crises is also observable for e_0 (1.9, 2.9, 4.5), male e_0 (0.7, 1.1, 1.9), female e_0 (0.5, 1.0, 1.4), mortality due to transportation injuries, infectious and parasitic diseases, AND mortality at ages 0-14, 30-44, and 75+. The mortality gradient is not observed for CVD, IHD, and respiratory disease, but for these three cause-specific mortality rates the greatest reduction in 2007-2010 occurred in the group of countries in which the recession had been the most severe. Thus considering multiple health indicators including general and sex-specific mortality as well as mortality owning to major causes of death the largest improvement between 2007 and 2010 is observed in the countries where the severity of the recession was the highest.

Suicides depart from the pattern of most other mortality categories, as in the three groups of countries they evolved better in 2004-2007 than in 2007-2010. But in the later recession years, suicides only increased in the countries where the recession was mild—where they increased by 0.2%—or moderate—where they increased by 6.0% (Table 2,

panels A and B)—, while surprisingly they decreased by 1.6% in the countries where the recession was severe (Table 2, panel C).

As measured by e_{65} and mortality at ages 75 and older, mortality of the elderly improved more during the recession in the countries most affected by the crisis (Table 2, panel C), but improved more during the expansion years in the countries with mild or moderate recession.

The Baltic states, Spain, Greece and Slovenia, where the recession has been the most severe (Figure 4, Figure 5, bottom panel), had gains in e_0 that were greater in the 2007-2010 recession than in the 2004-2007 expansion (Table 1). The Baltic states are the extreme case. In the three of them e_0 had a substantial gain of over 2.5 years in 2007-2010, but in two of them, Latvia and Lithuania, e_0 had *decreased* in 2004-2007 (Table 1, Figure 1). Germany and Austria are the only two countries in the sample in which unemployment rates did not increase between 2007 and 2010 (Figure 1, Table 1). However, in this period these two countries performed poorly in terms of population health: e_0 increased in both 0.4 years, which is a third of Greece's gain and a seventh of Estonia's gain in the same three-year period.

The descriptive evidence for 2004-2007 and 2007-2010 shows consistently that for most health indicators, changes in unemployment—which is an index of the severity of the crisis—correlate positively with improvements in health.

5. Regression Analysis

Results of regressions computed with models like equation [1], and a sample including the years 2004-2010 (Table 3, panel A) show that rising unemployment is associated with general improvements in health indicators. Thus a percentage point increase in the unemployment rate associates with rising e_0 (for the general population as well as males and females) and e_{65}, as well as with reductions of age-standardized mortality by all causes (by 0.5%), by CVD (by 0.3%), IHD (by 0.3%), by respiratory disease (by 1.0%), by transportation injuries (2.1%), and mortality for ages 30-44 (by 1.2%), and 75+ (by 0.2%). When the sample is expanded to the years 2001-2010 (Table 3, panel B), or to the period 1995-2013 (Table 3, panel C) the effects are basically the same. The expansion of

the sample tends to reduce the size of the effect though the levels of statistical significance are very similar. In the three samples the effect estimate for suicides is positive, suggesting a level of suicides positively correlated with the unemployment rate, but in all samples the effect is not statistically significant at the usual 95% level of confidence.

During the decade 2001-2010, the mean annual increase of e_0 was 0.27 years in our 27-country sample. Since our model shows that one percentage-point increase in the unemployment rate is associated with an extra e_0 gain of 0.058 years (Table 3), a decrease of the unemployment rate by 5 percentage points or more will be associated with a reversal of the annual gain in e_0, as $0.27 - 5 \cdot 0.058 = -0.02$. Thus the models predicts that a strong economic expansion in which unemployment falls by more than 5 percentage points will reverse the long-term rising trend in e_0, leading to a reduction of e_0. Apparently this is what occurred in Lithuania and Latvia in the period 2004-2007 (Figures 2 and 5, top panel), when the economy boomed, unemployment decreased by several percentage points, and e_0 reversed its long-term decreasing trend.

Models using nonlinear detrending (Table 4) of unemployment and mortality rates provide confirmation of the results obtained with linear detrending (Table 3). Using the HP filter for detrending either with a smoothing parameter $\gamma = 100$ (Table 4, panel B) or $\gamma = 6.25$ (Table 4, panel A) we found statistically significant effects consistent with a procyclical oscillation of mortality due to all causes, CVD, IHD, respiratory diseases and transportation injuries. Similarly, positive and statistically significant effects of unemployment on e_0 (stronger for males) in the non-linear models (Table 4), indicate a countercyclical oscillation of e_0 which is consistent with the procyclical oscillation of mortality rates. However, the link between the business cycle and mortality for all causes as well as e_{65} and female e_0 appears clearly when the HP-filter for non-linear detrending is applied with $\gamma = 100$ (Table 4, panel B) and less so when it is applied with $\gamma = 6.25$ (Table 4, panel A). We believe that the HP-filter applied with a smoothing parameter $\gamma = 6.25$ eliminates to a substantial extent the oscillations corresponding to the so-called business cycle.

While suicide appears acyclical or very weakly countercyclical using linear detrending (Table 3 of the paper) it appears clearly countercyclical in models using non-linear detrending (Table 4), whatever the smoothing parameter used for the HP filter.

6. Discussion

The procyclical oscillation of mortality that had been found by different investigators using historical data of the United States (Ogburn and Thomas 1922; Tapia Granados and Diez Roux 2009; Eyer 1977a; Ruhm 2000) has appeared missing in some data for recent years (McInerney and Mellor 2012; Ruhm 2015a), a finding that has generated some controversy (Lindo 2015). What our results show, however, is that considering the most recently available data from Europe, there is outstanding evidence of a procyclical oscillation of mortality. We show that a procyclical oscillation of mortality is observable in the period 1995-2013 in Europe, and particularly in the period 2004-2010 including the early years of the Great Recession and the previous expansion. We found that, as measured by a variety of major health indicators, population health in 2001-2010 evolved better during the recession than during the expansion, with the size of the annual improvement in population health being correlated with the increase in unemployment. As Gerdtham and Ruhm (2006) found in a panel of OECD countries, death rates tend to rise in periods of economic expansion so that, consistently with previous experience, in 2007-2010 there were major gains in health precisely in the countries where the crisis was more severe. Using as dependent variable e_0, $e_{65,}$ total mortality and cause-specific mortality for CVD, IHD, respiratory disease, and transportation injuries, we found evidence of a procyclical oscillation of mortality that is consistent across regression models (Tables 3 and 4, Tables B1 and B2 in appendix B). With very few exceptions, our analyses with different model specifications and sub-samples show that the deterioration of macroeconomic conditions indexed by the increase in the unemployment rate is correlated with improvements in health indicators. Our analyses do not suggest a significant relation of infant mortality and mortality at ages 0-14 with the fluctuations of the economy.

Our results are robust to the selection of variable to weight the observations in the regression as well as to the selection of economic indicator to be used as business-cycle indicator (Tables 3 and 4). Models in which the economy is indexed by the unemployment rate are better to reveal the procyclical oscillation of death rates, as standard errors are smaller and levels of significance higher. Nevertheless, we find macroeconomic effects on mortality in the same direction when using as economic indicator the EPR (Table B2, appendix B), or GDP per capita (Table B1, appendix B), which is the economic indicator that performs worst to reveal the macroeconomic effect on mortality. In all specifications and models mortality rates at middle age (30-44) and advanced age (75+) show a clear procyclical oscillation. However, mortality at ages 30-44 is more responsive to macroeconomic change and the effect appears systematically in all models (Tables 3 and 4, Table B1 in appendix B). This contrasts with some claims that in the United States procyclical mortality is mostly a phenomenon of advanced ages (Miller et al. 2009; Stevens et al. 2011).

Since the present investigation has focused on a reduced time period, we did not try to study lagged effects. It might be worth mentioning, though, that findings of lagged harmful effects of recessions on health reported in the past by Brenner (1983) have never been confirmed by other researchers (Winter 1983; Wagstaff 1985; Tapia Granados and Ionides 2008; Tapia Granados 2012). Brenner's studies have received a variety of criticisms (Wagstaff 1985; Cook and Zarkin 1986; Kagan 1987; Eyer 1977b; Kasl 1979; Ruhm 2006, 2008) which have led to considerable skepticism about Brenner's data and conclusions (Kasl and Jones 2000).

Our results for suicides are inconclusive and somewhat surprising. Many studies have found suicides fluctuating countercyclically, i.e. increasing in recessions, in different countries and periods (Waldron and Eyer 1975; Eyer 1977a; Boor 1980; Bollen 1983; Plaut and Anderson 1999; Ruhm 2000; Tapia Granados 2005, 2008; Khang et al. 2005; Tapia Granados and Diez Roux 2009; Luo et al. 2011; Ionides et al. 2013; Chang et al. 2013). Indeed, focusing on morbidity rather than mortality, Ruhm (2005) found that in the United States mental health tends to be procyclical, while physical health is countercyclical (Ruhm 2005). This would be consistent with a countercyclical oscillation

of suicides and a procyclical oscillation of deaths due to physical ailments such as heart attacks, respiratory diseases or physical injuries. However, some investigations on suicides in European countries found suicides oscillating procyclically, increasing in expansions, in Finland (Hintikka et al. 1999) and Germany (Neumayer 2004), and unrelated to the business cycle in Sweden (Tapia Granados and Ionides 2011), and there has been disagreement on whether suicides in the Baltic states have increased significantly during the Great Recession (Reeves et al. 2012; Stankunas et al. 2013; Reeves et al. 2013). In our investigation the increase in suicides associated with higher levels of unemployment is not statistically significant in most models and samples. Our main model (Table 3) shows no significant relation of suicides with macroeconomic conditions at the usual levels of confidence. However, we find a significant countercyclical fluctuation of suicides in the models with variables detrended by non-linear methods (Table 4).

The size of the macroeconomic effect on mortality that we report is similar to what was found in previous investigations. With 2004-2010 data, we found that a one-percentage point increase in the national unemployment rate is associated with a 0.5% decrease in mortality; the effect goes down to 0.4% and 0.3% respectively with 2001-2010 data and with 1995-2013 data (Table 3). These effects are very similar to the 0.5% and 0.4% mortality reductions per percentage-point increase in unemployment that were respectively found by Ruhm (2000) with 1972–1991 data from the states of the USA and by Gerdtham and Ruhm (2006) in a 1960–1997 panel of 23 OECD countries. However, Toffolutti and Suhrcke (2014) reported much larger effects. Considering mortality *at ages below 65* and using a 2003-2010 panel for 23 European Union countries Toffolutti and Suhrcke found a one percentage point increase in the national unemployment rate associated ay high levels of statistical significance with a 3.4% decrease in age-adjusted mortality for ages below 65, a 3.7% reduction of mortality due to CVD, a 11.5% reduction of mortality due to motor-vehicle traffic injuries, and a 4.1% increase of suicides. Considering *mortality at all ages* we found associations in the same direction but with a 0.4% reduction of CVD mortality (P <0.001), a 2.2% reduction in traffic mortality (P < 0.001), and a 0.7% marginally significant increase of suicides (P =

0.069). Thus the always highly significant effect estimates of Toffolutti and Suhrcke are between five and eight times bigger than ours, which does not seem to be justified by the difference in dependent variable (all-ages mortality for us, mortality at ages below 65 for them).

We have also tried to replicate Toffolutti and Suhrcke's results for all-cause mortality at ages below 65 by fitting models as close as possible to the one reported by Toffolutti and Suhrcke. The effect estimates we found were around -1.0%, that is, between three and four times smaller than Toffolutti and Suhrcke's estimate.

Our conclusion is that Toffolutti and Suhrcke's outsized effects always at high levels of statistical significance may be due to a numerical mistake or a misspecification of the model.[2]

Considering long-run trends, since the 19th century age-specific mortality rates have declined, while GDP per capita has increased in every country. At any given year, higher levels of GDP per capita are thus associated with lower levels of mortality and higher levels of e_0. This has promoted the view that "wealthier is healthier" (Pritchett and Summers 1996), that increasing levels of income are always associated to increased levels of health. However, the distribution of e_0 and GDP per capita in different decades of the 20th century led Samuel Preston to conclude that only a minor part of past gains in e_0—about 20%—could be attributed to rising income (Preston 1976, 1996). Cross-country data show "almost no relation between changes in life expectancy and economic growth over 10, 20, or 40-year time periods between 1960 and 2000," so that in many countries there have been "remarkable improvements in health with little or no economic growth" (Cutler et al. 2006). Amartya Sen found that the rate of decline of mortality in Britain between 1900 and 1970 revealed an inverse relationship with economic growth, with decades of high economic growth associated with low increases in life expectancy (Sen 2001) a relation that is also found for most of the 20th century in a year-to-year analysis

[2] Toffolutti and Suhrcke's model includes the logarithm of real GDP per capita as covariate. The inclusion of this variable which is strongly correlated with the unemployment rate (both are business-cycle indicators) potentially complicates the interpretation of the coefficient for unemployment. At any rate, in our attempts to replicate Toffolutti and Suhrcke's model we find the effect of GDP per capita not statistically significant, and both including or excluding it from the model we get estimates of around –1.0% for the unemployment rate effect on mortality, much smaller than Toffolutti and Suhrcke's estimates .

(Tapia Granados 2012). For Samuel Preston, to obtain gains in health levels no longer requires economic growth (Preston 2007). This idea is quite difficult to accept for some researchers (Mackenbach 2007), but it is quite consistent with the results of this investigation, which adds the recent European experience to the body of literature showing that, in the short run, economic recessions are rather beneficial for a variety of health outcomes. This well-documented historical phenomenon has been reported to be weakening in recent years in the United States (Ruhm 2013), as well as in recent years in other countries (Tapia Granados 2008, 2012) but apparently remains evident in recent years when the overall experience of the European countries since 2000 is considered.

The association of faster reductions in mortality with rising unemployment when there is an economic downturn is counterintuitive because it is at odds with research that has shown (*a*) that compared with employed, unemployed individuals have worse health outcomes; and (*b*) that there is a strong health gradient by social class, so that higher income correlates with better health. In recessions, joblessness increases and income declines for most people. *Others thing being equal*, we should then expect that mortality increased in recessions or at least that it decreased less the more severe is the downturn. However, what we observe is that mortality accelerates its declining trend when the economy slows down. The explanation must be that *other things are not equal* and some important determinants of ill health and death are correlated with economic activity. For traffic-related mortality, the cyclical mechanism seems quite apparent, since economic downturns reduce industrial and commercial traffic, as well as commuting and recreational driving. Expansions also bring overtime hours and higher intensity of work, as well as hiring of new workers who are inexperienced and more prone to industrial injuries. Another explanation of procyclical death rates is atmospheric pollution, which rises in expansions and falls in recessions (Davis et al. 2010). We found a significant positive correlation of the decline in respiratory mortality with the severity of the recession in 2007-2010 (Table 2) and in the panel 2001-2010 one-percentage-point increase in the unemployment rate is associated with a 1.0% reduction in respiratory disease mortality (Table 3, panel B). In the countries where the crisis has been severe respiratory disease mortality dropped by 16.1% in 2007-2010 and just by 3.2% in 2004-

2007 (Table 2). Thus atmospheric pollution seems a key mechanism linking macroeconomic fluctuations with mortality through respiratory-disease and CVD deaths. This is consistent with the fact that daily hospitalizations and deaths due to acute respiratory or cardiovascular ailments increase when atmospheric pollution is higher (Schwartz 1994; Jerrett et al. 2005; Dominici et al. 2006; Pope and Dockery 2006; Lisabeth et al. 2008). For Heutel and Ruhm (2013) procyclical atmospheric pollution explains about a third of the procyclical oscillation of mortality in the United States.

Other potential mechanisms linking macroeconomic swings with mortality oscillations are work-environment factors, with slower rhythms of work and less overtime leading to less occupational stress and more time for sleep, physical activity, and social interaction, which is health promoting (Eyer 1977a, 1980; Sterling and Eyer 1981, 1988; Biddle and Hamermesh 1990; Edwards 2011). More commuting and internal migration resulting from upturns in business activity might lead to an enhanced circulation of pathogens (Ionides et al. 2013). More frequent mild infections and higher pollution would increase the risk of acute cardiorespiratory events in persons carrying CVD or respiratory chronic disease (Ruhm 2008). Social isolation and cigarette smoking also increase in expansions and decrease in recessions (Gerdtham and Ruhm 2006; Edwards 2011; Xu 2013) and may also be contributors to the increased risk of death in economic expansions.

Migration causing unaccounted changes in the national population can change mortality rates, but this would be an unlikely explanation for the changes in the age-adjusted health indicators we have used in this investigation, that according to WHO are reasonably comparable for the countries in our sample (WHO Regional Office for Europe 2014a, Technical Notes). Furthermore, the sizable gains in population health during the recession years are observed in countries like Ireland or Spain, which had sustained population growth throughout the decade, but also in countries like the Baltic states, which had sustained population decline between 2001 and 2010 (Table B3, Appendix B). The consistency of our results for males and females and across mid and advanced ages also reduces the credibility of the hypothesis that our results can be determined by population displacements.

According to WHO estimates (WHO Regional Office for Europe 2014a) total health expenditure measured as percentage of GDP had a marked peak in 2009 in most European countries, with substantial drops between 2009 and 2010 in Austria, Czech Republic, France, Germany, Greece, Ireland, Lithuania, Poland, Portugal, Slovakia, Slovenia, Spain, Sweden, and Switzerland. Total health expenditure, measured in units of purchasing power parity per capita, peaked in Latvia in 2007, in Ireland and Lithuania in 2008, and in most other countries of our sample in 2009 (Figures B1 and B2, appendix B). Thus we found large gains in population health in 2007-2010 in Greece, Slovakia, Spain, and the Baltic states, where the recession has been the most severe and austerity policies have been applied at least from 2009. In Latvia, when major health expenditure cuts took place between 2007 and 2010 there was a gain of 2.5 years in e_0, while e_0 decreased by a tenth of a year in 2004-2007, when the economy was booming and health spending was quickly increasing. All this evidence does not seem compatible with recent claims that reductions in health spending have had major harmful effects on population health (Karanikolos et al. 2013; Stuckler and Basu 2013). Besides health spending being cut, the provision and the quality of health care services may have deteriorated in many European countries in which austerity policies have been applied (Pavolini and Guillén 2013; García Rada 2012; Kondilis et al. 2013). If that is the case, as very likely is, our findings suggest that a substantial deterioration in health care may not have a short-run effect on mortality (McKinlay et al. 1989).

Acknowledgements

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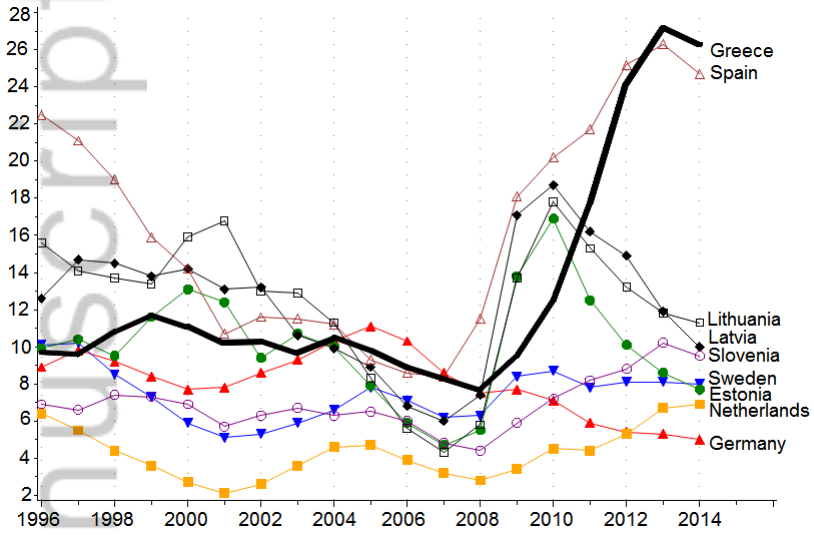
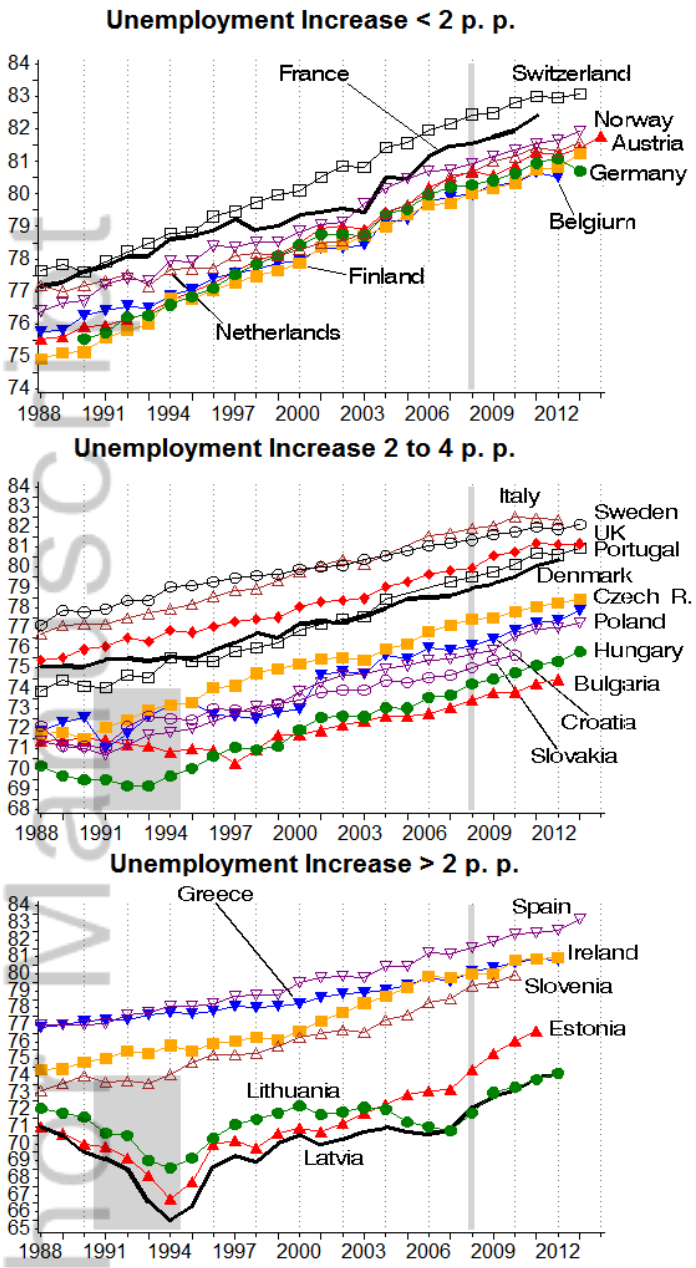
Figure 1. Unemployment rates (as percentage of the economically active population) of nine European countries, 1996-2014



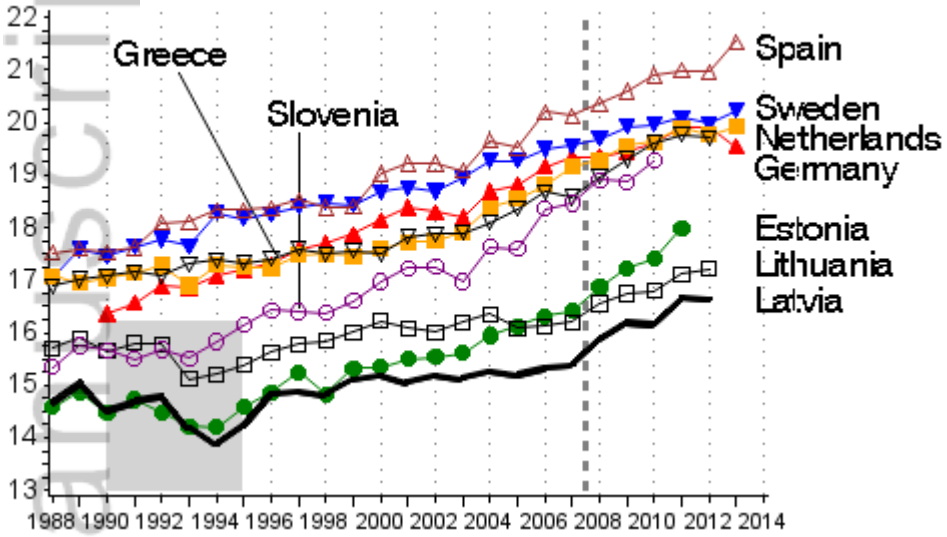
Data source: WDI.

Figure 2. Life expectancy at birth (years) in 27 European countries sorted by the unemployment increase (in percentage points) between 2007 and 2010. The recession was mild in the countries included in the upper panel, moderately severe in the countries of the mid panel and severe in the countries of the bottom panel. In that panel the gray rectangle in the early 1990s corresponds to the transition to a market economy in Eastern European countries. The gray vertical bar in the three panels represents the start of the Great Recession



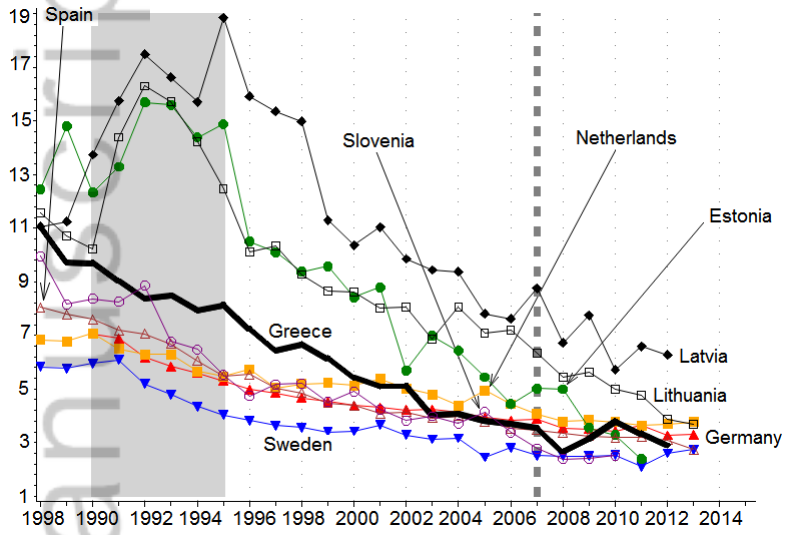
Data source: HFA-DB

Figure 3. Life expectancy (years) at age 65 in nine European countries. The shaded area in the early 1990s represents the transition to a market economy in Eastern Europe; the start of the Great Recession is represented by a dashed vertical line



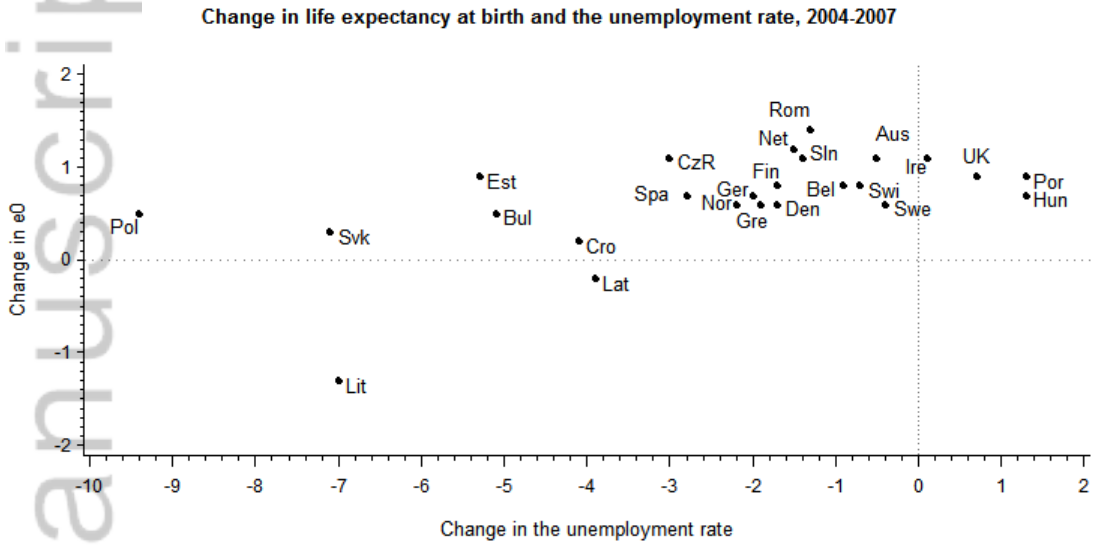
Data source: HFA-DB

Figure 4. Infant mortality rate (deaths of children below age 1 per 1000 live births) in nine European countries. The shaded area in the early 1990s represents the transition to a market economy in Eastern Europe, the start of the Great Recession is represented by a dashed vertical line



Data source: HFA-DB

Figure 5. Changes in the unemployment rate and in life expectancy at birth (e_0) in the three-year periods before and after the start of the great recession



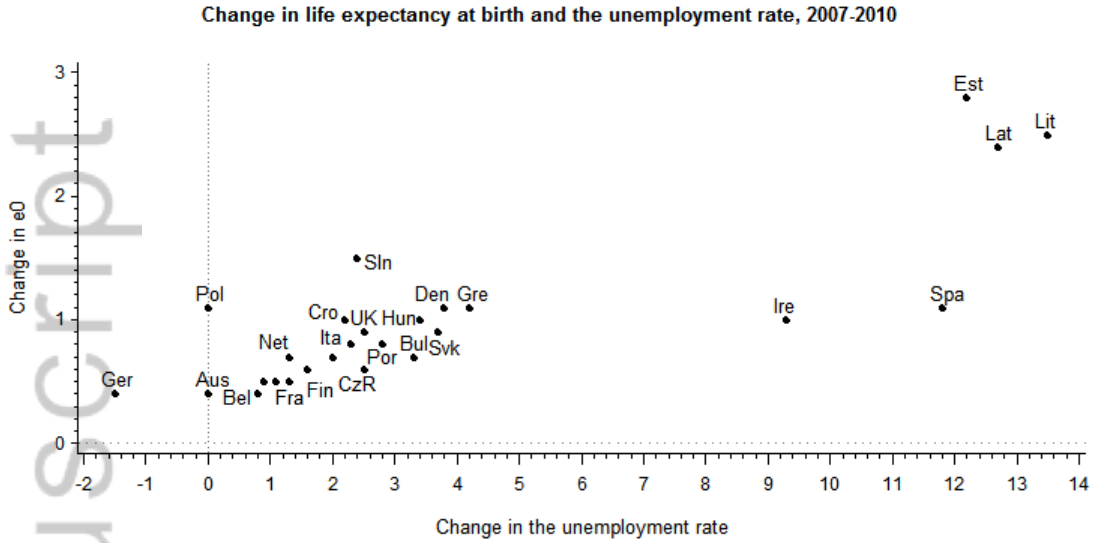


Table 1. Life expectancy at birth (e_0, in years) and unemployment rate (U, %) in 2004, 2007 and 2010 in 27 European countries. Δe_0 and ΔU are the changes (between 2004 and 2007 and between 2007 and 2010) in both variables.

Year	Country	U	ΔU	e_0	Δe_0	Country	U	ΔU	e_0	Δe_0
2004	Austria	4.9	.	79.4	.	Latvia	9.9	.	71.0	.
2007		4.4	-0.5	80.5	1.1		6.0	-3.9	70.8	-0.2
2010		4.4	0.0	80.9	0.4		18.7	12.7	73.2	2.4
2004	Belgium	8.4	.	79.1	.	Lithuania	11.3	.	72.1	.
2007		7.5	-0.9	79.9	0.8		4.3	-7.0	70.8	-1.3

2010		8.3	0.8	80.3	0.4		17.8	13.5	73.3	2.5
2004	Bulgaria	12.0	.	72.6	.	Netherland	4.6	.	79.4	.
2007		6.9	-5.1	73.1	0.5		3.2	-1.4	80.5	1.1
2010		10.2	3.3	73.8	0.7		4.5	1.3	81.2	0.7
2004	Croatia	13.7	.	75.7	.	Norway	4.4	.	80.2	.
2007		9.6	-4.1	75.9	0.2		2.5	-1.9	80.8	0.6
2010		11.8	2.2	76.9	1.0		3.6	1.1	81.3	0.5
2004	Czech R.	8.3	.	76.0	.	Poland	19.0	.	75.0	.
2007		5.3	-3.0	77.1	1.1		9.6	-9.4	75.5	0.5
2010		7.3	2.0	77.8	0.7		9.6	0.0	76.6	1.1
2004	Denmark	5.5	.	78.0	.	Portugal	6.7	.	78.4	.
2007		3.8	-1.7	78.6	0.6		8.0	1.3	79.3	0.9
2010		7.5	3.7	79.5	0.9		10.8	2.8	80.1	0.8
2004	Estonia	10.0	.	72.3	.	Romania	7.7	.	71.9	.
2007		4.7	-5.3	73.2	0.9		6.4	-1.3	73.3	1.4
2010		16.9	12.2	76.0	2.8		7.3	0.9	73.8	0.5
2004	Finland	8.8	.	79.0	.	Slovenia	6.3	.	77.3	.
2007		6.8	-2.0	79.7	0.7		4.8	-1.5	78.5	1.2
2010		8.4	1.6	80.3	0.6		7.2	2.4	80.0	1.5
2004	France	9.2	.	80.5	.	Spain	11.2	.	80.5	.
2007		8.0	-1.2	81.5	1.0		8.4	-2.8	81.2	0.7
2010		9.3	1.3	82.0	0.5		20.2	11.8	82.3	1.1
2004	Germany	10.3	.	79.4	.	Slovakia	18.1	.	74.4	.
2007		8.6	-1.7	80.2	0.8		11.0	-7.1	74.7	0.3
2010		7.1	-1.5	80.6	0.4		14.4	3.4	75.7	1.0
2004	Greece	10.5	.	79.0	.	Sweden	6.6	.	80.6	.
2007		8.3	-2.2	79.6	0.6		6.2	-0.4	81.2	0.6
2010		12.5	4.2	80.7	1.1		8.7	2.5	81.8	0.6
2004	Hungary	6.1	.	73.0	.	Switzerland	4.3	.	81.4	.
2007		7.4	1.3	73.7	0.7		3.6	-0.7	82.2	0.8
2010		11.2	3.8	74.8	1.1		4.5	0.9	82.8	0.6
2004	Ireland	4.5	.	78.7	.	UK	4.7	.	79.0	.
2007		4.6	0.1	79.8	1.1		5.4	0.7	79.9	0.9
2010		13.9	9.3	80.8	1.0		7.9	2.5	80.8	0.9
2004	Italy	7.9	.	.	.					
2007		6.1	-1.8	81.7	.					
2010		8.4	2.3	82.5	0.8					

Sources: e_0 data from HFA-DB, unemployment rates from WDI.

Table 2. Mean unemployment rate, mean levels of 15 indicators of population health in 2004, 2007, and 2010, and absolute and relative changes between the means for these years in 27 countries sorted in three groups according to the severity of the economic recession in 2007-2010

		e_0					Age-standardized death rate per 100,000 populations										
	U	M&F	M	F	e_{65}	IMR	All cause	CVD	IHD	Rsp. dis.	Trsp. inj.	I&PD	Suicide	Ages 0-14	Ages 30-44	Ages 75+	
2004	8.3	79.6	76.5	82.4	19.0	4.1	617.5	222.2	88.0	40.5	8.2	8.8	14.0	43.8	110.9	7781.8	A. Countries with mild or no economic crisis
2007	6.8	80.4	77.4	83.2	19.6	3.8	577.2	198.7	76.4	38.4	7.1	8.7	12.5	39.9	98.8	7314.8	
2010	7.1	80.9	78.1	83.7	20.0	3.5	552.3	178.0	68.1	34.6	5.6	8.8	12.6	36.6	93.0	7020.6	
Change 2004-7	-1.5	0.8	0.9	0.8	0.6	-0.3	-40.3	-23.5	-11.6	-2.0	-1.1	-0.1	-1.4	-3.9	-12.1	-467.0	
Change 2007-10	0.3	0.5	0.7	0.4	0.4	-0.3	-24.9	-20.7	-8.3	-3.8	-1.5	0.1	0.0	-3.3	-5.8	-294.2	
% change 2004-7	-17.8	1.1	1.2	1.0	3.4	-8.0	-6.5	-10.6	-13.1	-5.0	-13.3	-1.2	-10.3	-8.9	-10.9	-6.0	
% change 2007-10	4.7	0.7	0.9	0.5	1.9	-8.2	-4.3	-10.4	-10.9	-9.9	-21.1	0.7	0.2	-8.3	-5.9	-4.0	
2004	9.0	76.3	73.0	79.6	17.1	6.6	805.7	364.5	143.4	53.5	11.6	7.5	12.8	69.2	160.9	9392.5	B. Countries with moderate economic crisis
2007	6.8	77.9	74.8	81.0	18.1	5.2	713.1	300.3	119.7	48.6	10.3	8.3	10.1	54.7	136.5	8456.9	
2010	9.1	78.8	75.7	81.8	18.6	4.5	667.1	272.7	107.3	45.5	7.4	8.0	10.7	46.4	120.8	8017.1	
Change 2004-7	-2.2	1.6	1.7	1.5	1.0	-1.4	-92.7	-64.2	-23.7	-4.8	-1.3	0.8	-2.7	-14.4	-24.3	-935.6	
Change 2007-10	2.4	0.9	1.0	0.8	0.5	-0.7	-45.9	-27.6	-12.4	-3.1	-2.9	-0.3	0.6	-8.4	-15.7	-439.8	
% change 2004-7	-24.5	2.1	2.3	1.8	6.0	-21.9	-11.5	-17.6	-16.5	-9.1	-10.9	10.2	-21.1	-20.9	-15.1	-10.0	
% change 2007-10	35.0	1.1	1.3	1.0	2.9	-13.2	-6.4	-9.2	-10.3	-6.4	-28.0	-3.2	6.0	-15.3	-11.5	-5.2	
2004	10.4	76.8	73.2	80.5	17.6	6.1	778.7	367.0	145.1	48.5	14.2	9.1	12.6	67.1	178.2	9209.7	C. Countries with severe economic crisis
2007	6.9	77.4	73.7	81.1	18.0	5.0	751.0	339.3	130.2	50.1	13.0	9.5	10.2	57.2	175.0	8764.0	
2010	16.2	78.8	75.3	82.2	18.8	4.6	671.8	300.6	111.0	42.0	7.9	8.0	10.1	49.7	142.0	8039.3	
Change 2004-7	-3.5	0.5	0.5	0.5	0.4	-1.1	-27.8	-27.7	-14.9	1.6	-1.2	0.4	-2.4	-9.9	-3.3	-445.7	
Change 2007-10	9.2	1.4	1.6	1.1	0.8	-0.4	-79.1	-38.7	-19.2	-8.1	-5.1	-1.5	-0.2	-7.6	-32.9	-724.7	
% change 2004-7	-33.3	0.7	0.7	0.7	2.3	-18.1	-3.6	-7.5	-10.3	3.2	-8.4	3.9	-19.1	-14.7	-1.8	-4.8	
% change 2007-10	133.3	1.9	2.2	1.4	4.5	-8.7	-10.5	-11.4	-14.8	-16.1	-39.6	-15.4	-1.6	-13.2	-18.8	-8.3	

Means weighted by the square root of population. The unemployment rate (U) is in percentage of the economically active population. Life expectancies at birth (e_0) and age 65 (e_{65}) are in years. IMR is infant mortality rate (deaths of children less than 1 year of age per 1000 live births the same year); CVD is cardiovascular disease, IHD is ischemic heart disease, I&PD is infectious and parasitic disease. All data from the European HFA database of WHO. Panel A countries are those with mild or no recession ($\Delta U < 2$ percentage points between 2007 and 2010): Austria, Belgium, Finland, France, Germany, the Netherlands, Norway, and Switzerland. Panel B are countries with mild recession (ΔU between 2 and 4 percentage points): Bulgaria, Croatia, Czech Republic, Denmark, Hungary, Italy, Poland, Portugal, Slovakia, Sweden, and the UK. Panel C includes countries with severe recession ($\Delta U > 4$ percentage points): Estonia, Greece, Ireland, Latvia, Lithuania, Slovenia, and Spain.

Table 3. Regression estimates of the change in an indicator of population health associated with a percentage point increase in the unemployment rate. Data for 27 European countries in the specified years

	A Sample 2004-2010	B Sample 2001-2010	C Sample 1995-2013
Life expectancy at birth (e_0)	0.078**	0.058**	0.044***
e_0 males	0.095**	0.071**	0.052***
e_0 females	0.051**	0.038**	0.031**
Life expectancy at age 65 (e_{65})	0.025***	0.021***	0.017***
Infant mortality rate	0.002	0.001	-0.001
Age-standardized mortality:			
All causes	-0.005***	-0.004***	-0.003**
Cardiovascular disease	-0.003**	-0.003*	-0.001
Ischaemic heart disease	-0.003*	-0.002**	-0.001
Infectious & parasitic disease	-0.001	-0.004	-0.008
Respiratory diseases	-0.010*	-0.010**	-0.007**
Transportation injuries	-0.021***	-0.022***	-0.017***
Suicide	0.006†	0.004	0.003
Ages 0-14	-0.005	-0.003	-0.004*
Ages 30-44	-0.012***	-0.009***	-0.007***
Ages 75 and older	-0.002*	-0.001†	-0.001

The sample includes observations for Austria, Belgium, Bulgaria, Croatia, the Czech Republic, Denmark, Estonia, Finland, France, Germany, Greece, Hungary, Ireland, Italy, Latvia, Lithuania, Netherlands, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, and the UK. All estimates are based in regressions in which e_0, e_{65} or the natural logarithm of a mortality rate is modeled as a function of a constant, the national unemployment rate, fixed effects for year and state, and country-specific linear trends, with observations weighted by the square root of the country's population. Because of missing data for particular years, countries, or health indicators the number of observations included in the regressions was 176 in the sample 2004-2010, between 255 and 257 in the sample 2001-2010, and between 390 and 392 in the sample 1995-2013. The levels of statistical significance are indicated by *P<0.05, **P < 0.01, ***P<0.001, and †P<0.1. They are computed with robust standard errors adjusted for repeated

Table 3. Regression estimates of the change in an indicator of population health associated with a percentage point increase in the unemployment rate. Data for 27 European countries in the specified years

observations in each country.

Table 4. Estimate for the effect of the unemployment rate in regression models in which an indicator of population health is regressed on the national unemployment rate and a fixed effect for year, with both the dependent variable and the covariate detrended by subtracting a Hodrick-Prescott (HP) trend computed with a smoothing parameter $\gamma = 6.25$ or $\gamma = 100$

	Panel A: Series HP-detrended with $\gamma = 6.25$			*Panel B:* Series HP-detrended with $\gamma = 100$		
Dependent variable	Sample 2004-2010	Sample 2001-2010	Sample 1995-2013	Sample 2004-2010	Sample 2001-2010	Sample 1995-2013
Life exp. at birth (e_0)	0.037*	0.029*	0.033**	0.051**	0.052***	0.047**
e_0, males	0.048*	0.037*	0.041**	0.06**	0.059***	0.053**
e_0, females	0.020	0.015	0.019*	0.036**	0.039***	0.033***
Life exp. at age 65 (e_{65})	0.002	0.003	0.006	0.016**	0.021***	0.015**
Infant mortality rate	0.000	0.001	0.000	-0.001	-0.001	-0.001
Age-standardized mortality:						
All causes	-0.002	-0.002†	-0.002**	-0.003**	-0.003***	-0.003**
Cardiovascular disease	-0.001	0.000	-0.002†	-0.002*	-0.002**	-0.002†
Ischaemic heart dis.	-0.001	-0.001	-0.002†	-0.002†	-0.003*	-0.003**
Infect. & paras. dis.	-0.003	-0.002	-0.004	-0.006	-0.005	-0.005
Respiratory diseases	-0.010***	-0.008*	-0.005†	-0.010***	-0.009***	-0.009***
Transport. injuries	-0.014**	-0.013**	-0.012***	-0.014**	-0.014***	-0.012***
Suicide	0.009**	0.007**	0.004*	0.006*	0.004*	0.005**
Ages 0-14	-0.004†	-0.002	-0.004*	-0.003	-0.003†	-0.004***
Ages 30-44	-0.008***	-0.007***	-0.007***	-0.009***	-0.008***	-0.008***
Ages 75 and older	0.001	0.001	-0.001	-0.001†	-0.001†	-0.002*

The 27 countries included are those listed in Table 3. All estimates are based in regressions in which a detrended series of a health

indicator (e_0 or e_{65} in years, or the natural logarithm of a mortality rate) is modeled as a function of a constant, the detrended national unemployment rate and a fixed effect for year, with observations weighted by the square root of the country's population. Robust standard errors are computed considering autocorrelation in each country series. The number of observations included in the regressions was 189 for the 2004-2010 sample, 270 for the 2001-2010 sample, and between 486 and 491 for the 1995-2013 sample.

*** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, † $P < 0.1$.

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