Total and Cause-Specific Mortality Rates Before and During the Greek Economic Crisis: An Interrupted Time-Series Analysis

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Abstract

Background: In recent years, Greece has been in the spotlight as one of the countries hit the hardest by the European financial crisis. Yet evidence on the impact of the crisis on total and cause-specific mortality remains unclear. The paper explores whether the economic crisis has interrupted the level and/or the trend of mortality rates.

Methods: We use regional panel data for the period 2001-2013 and adopt an interrupted time-series approach in order to test for any changes in a series of gender, age and cause-specific mortality trends.

Findings: Our results show that overall mortality has continued to decline during the years of the financial crisis but at a slower pace (-0·13 vs. -0·065) and the trend difference is statistically significant (0·062, $p<0·001$). The trend difference is more evident for women (0·087, $p<0·001$) than for men (0·040, $p<0·01$). Older age groups have experienced more negative effects than the younger population, who have even seen some improvements in mortality trends. Deaths by diseases of the circulatory system have declined more slowly, while deaths from vehicular accidents have declined faster during the crisis, most prominently among young men. On the other hand, deaths from suicides, diseases of the nervous system and mental disorders have followed a positive upward trend during the crisis. We also find evidence that deaths due to medical errors during treatment have increased considerably during the crisis, affecting mainly older adults. Comparing the expected values of the during-crisis versus extrapolated before-crisis fitted, one estimates an extra 241 deaths per month during the crisis period with the largest contributor being an excess of 153 deaths per month from circulatory causes.

Interpretation: The findings suggest that mortality trends have been interrupted during the years of the crisis, but that the changes vary by age, gender and cause of death. The increase of deaths due to medical errors may reflect the effects of quality deterioration during economic recessions.

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Research in context

Evidence before this study

Two of the authors (JI and CS) have been involved in a systematic literature review exploring the empirical evidence of the impact of the European financial crisis on health outcomes. In brief, the literature review explored the following databases: PUBMED, ISI Web of Knowledge, EBSCOhost, Scopus, and Google Scholar. In addition, we hand-searched key healthcare journals: *The Lancet*, the *European Journal of Public Health*, *Health Policy*, *Social Science and Medicine*, *The BMJ*, *PLoS One*, and *BMJ Open*. Finally, we reviewed number of relevant organisations' websites including the World Health Organisation, OECD, European Observatory on Health Systems and Policies, and UNICEF. We used the following search terms: 'financial crisis'; 'economic crisis'; 'recession'; 'austerity'; in conjunction with 'health'; 'health outcomes'; 'healthcare'; and 'Europe'. Our inclusion criteria included empirical, quantitative papers, published from January 2008, to December 2015. Our main exclusion criteria were: qualitative studies, opinion papers, commentaries and systematic literature reviews, conference proceedings and abstracts if the full text was not available. All selected studies were assessed for risk of bias.

Out of the 41 studies reviewed, only two looked at mortality trends in Europe; one focused on Spain and one compared Greece with Ireland and Finland. Both studies were confined in analysing data till 2011, which increase the risk of bias due to limited information into the crisis period. A number of studies (n=16) looked at suicides across Europe, but the evidence on other cause-specific mortality trends is limited. No evidence on deaths by medical errors was found.

Added value of this study

Our study adds to the ongoing international debate on the impact of economic crises on health outcomes by systematically analysing mortality rates in Greece, the country hit the hardest by the European financial crisis. For the first time we analyse data on deaths by medical errors, which have not been explored in other similar contexts previously. Methodologically, rather than expecting immediate jumps in mortality rates right at the start of the crisis and instead of comparing period-specific means our model, using regional panel data, allows us to test how health outcomes are affected as the crisis deepens.

Implications of all the available evidence

Financial crises are likely to interrupt mortality trends in ways which can vary considerably by age, gender and cause of death. Knowing the groups affected the most during recessions may help in planning appropriate policies and social protection schemes. The sharp increase of deaths by medical errors in a country that has reduced its health care expenditure substantially may reflect the effects of quality deterioration during economic recessions.

Introduction

Following the 2008 global financial crisis, Greece has been experiencing one of the most severe financial crises in its recent history, with uncontrolled public debt and an exponential increase in unemployment. The crisis has had a direct impact on the Greek health system, which faced financial difficulties and structural problems long before the crisis hit.(1) A number of health reforms, including the reduction in pharmaceutical expenditures and the structural reform of the social health insurance funds, had been on the policy agenda for over a decade but had never been implemented due to the lack of political will and the resistance of key stakeholders.(2) However, when they were finally enacted the Greek economy was already severely deteriorating. The implementation of public cuts resulted in a 25% reduction in health expenditures between 2008 and 2012.(3) Unemployment increased from 7.8% in 2008 to 27.5% in 2013 and was much higher among young groups,(4) making it even harder to finance the health system, which depends largely on social health insurance, and raising concerns regarding the erosion of health coverage among those without a job. In addition, the reforms were focused, by and large, on horizontal cost-cutting measures aimed to provide immediate effects and lacked any long-term considerations of the impact on equity of access and quality of care. A recent study revealed that the adverse economic environment had a notable impact on unmet health needs in Greece.(5)

The international evidence on the effect of economic crises on health is mixed. On the one hand, it is expected that during difficult economic periods, the reduction in health care spending compromises the quality of services provided, leading to a deterioration of health outcomes. In addition, reductions in household budgets, due to unemployment or reduction in pensions and wages, decrease individuals' ability to pay for health care, again leading potentially to deterioration of health outcomes. This seems more evident in countries with weaker social protection schemes.(6) On the other hand, it has been argued that during economic recessions, increases in tobacco and alcohol taxation may lead individuals to adopt healthier lifestyles, while traffic deaths are pro-cyclical and tend to decrease as unemployment increases due to a drop in the use of cars.(7) And still, how lifestyle behaviours change during recessions is not clear. During the Great Recession of 2008-2009 in the US, alcohol use declined overall but frequent binging increased, affecting mainly the young and unemployed.(8)

In Greece, concerns about the impact of the crisis on health outcomes were inevitable, and some authors started talking about a modern 'Greek tragedy.'(9) Yet the empirical evidence so far has been less conclusive. Vlachadis and colleagues(10) show a rising trend in total deaths among those older than 55 in 2011-12, while Tapia-Granados and Rodriguez,(11) comparing Greece with Iceland and Finland, argue that, after 2007, total deaths in Greece for most age groups continued to fall at the same rate as in previous years. A great number of studies have been conducted on suicides, showing an increase during the years of the economic crisis,(12-13) with the association being stronger among men of working age.(13-14) Very little is known about other causes of mortality.

The aim of our study is to explore whether the Greek financial crisis has affected the trend of overall and cause-specific mortality rates, looking at both men and women of different age groups. Rather than expecting immediate jumps in mortality rates at the start of the crisis and instead of comparing period-specific means, the interrupted time series estimator adopted here tests how health outcomes have been affected as the crisis has deepened.

Methods

Data sources and descriptive analysis

Our data source, provided by the Hellenic Statistical Authority (ELSTAT henceforth), contains monthly information regarding the number of deaths in Greece during the period between January 2001 and December 2013, by age, gender, region and cause. More specifically, the data report the total number of deaths by age category in five-year bands and by regions classified under the NUTS-II taxonomy (13 administrative regions). The total number of deaths is further disaggregated to 56 causes following the two-digit ICD classification. Our study focuses on overall mortality and on the main causes of death in Greece, including deaths from circulatory diseases, cancer, respiratory conditions, nervous system diseases and digestive diseases, as well as the main causes discussed in the literature on economic crises, including deaths from vehicular accidents, suicides, homicides, infectious diseases and conditions related to pregnancy and childbirth.(6,9) We focus also on causes that we hypothesize may be linked to the deterioration of health care during recession, such as deaths due to adverse events during medical treatment (see Appendix A1 for full list). Using publicly available Eurostat data on regional populations, we calculate the monthly age-standardized mortality rates per 100,000 inhabitants for each region.

Empirical strategy

Our empirical approach relies on the use of panel data containing sequential information before and during the crisis for every Greek region.(6,15) Our sample can be divided into two distinct sub-periods—a pre-crisis (2001m1-2008m8) period and a post- or during-crisis (2008m9-2013m12) period as previous evidence has shown,(16) We use all the available information so the data are not equally distributed before and after the onset of the crisis, however a visual inspection of the series indicates that the trends have not changed substantially before the crisis. Moreover, the obtained results were remarkably similar when the analysis was performed on a truncated sample where both the periods had had the same duration.

Despite the severity of the crisis, we should not expect a sharp change in mortality rates at the beginning of the recessionary period. It is more reasonable to assume that the adjustment of health outcomes, if any, should be more gradual—i.e., as the crisis deepens. Therefore, we can test whether mortality rate trends have changed during the crisis, as compared to the period before. Moreover, as every region was exposed to the debt crisis, there are no distinct treated and control regions in order to perform a difference-in-differences analysis. Instead, we test for changes in the slope of mortality rates by performing a single-group interrupted time series analysis (ITSA). To do so, we specified the following model:

$$M_{rt}^{c} = a_0 + a_1 T + a_2 \mathbb{I}\{T \geq \tilde{T}\} + a_3 (T - \tilde{T}) \times \mathbb{I}\{T \geq \tilde{T}\} + bX_{rt} + e_{rt}, \quad (1)$$

where M_{rt}^{c} is the age-standardized mortality rate for cause c in region r during month t; T is a running counter of months since the beginning of our sample; $\tilde{T}$ is a break point specified in the first month of the crisis period (2008m9); and X_{rt} is a vector containing regional fixed effects in order to account for permanent disparities across regions and interactions between regional and time indicators in order to control for seasonality, region-specific shocks and unobserved factors that may influence regional health outcomes (e.g. lifestyle habits, pressure from unrecorded migration etc.). According to this model specification, a_0 is the mean outcome level at the beginning of the study period; a_1 is the slope of the mortality rate before the crisis; a_2 indicates

whether the mean mortality level changed immediately after the onset of the crisis; and a_3 measures the difference between pre- and during-crisis mortality rate slopes. Hence, $a_1 + a_3$ measures the mortality trend during the crisis period. Since, by design, there are no comparable control regions in the single-group ITSA, the pre-crisis mortality trend projected into the second period is the counterfactual outcome that would have been observed if the crisis had not occurred (see Figure A2 of the appendix).(17) The models are estimated in Stata 14.1 via Ordinary Least Squares weighted by the regional population. A Wooldridge test (18) indicated the presence of within-region correlation, therefore the reported 95% confidence intervals (CIs) are based on standard errors that are corrected for clustering by region in order to account for omitted factors that evolve slowly over time and are not completely controlled for by the region-specific fixed effects. It should be mentioned that there could be a lag period between the onset of the recession and the observed changes in mortality rate trends. However, the exact time lag is unknown and it may vary substantially across genders, age groups and diseases. Nevertheless, a visual inspection of the data (see Figure 1) suggests that a gradual, continuous impact, modelled by a change in the mortality rate slope after the beginning of the recession, is a reasonable approximation. Moreover, in order to be reassured that there are not any outliers or nonlinearities in the relationship between mortality and time affecting our results, we performed some kernel-weighted local polynomial regressions, which indicated that the linear approximation fits the data quite well.

Results

Descriptive analysis

As shown in Table 1, age-standardized mortality rates have decreased considerably for both genders and across all age groups during the crisis as compared to the period before. With the exception of deaths from digestive and pregnancy-related diseases, for all other causes the changes in mean age-standardised death rates, positive or negative, are statistically significant (the change in mean homicide mortality is statistically significant at the 10% level).

[Insert Table 1 here]

Mortality trends

Figure 1 provides some initial graphical evidence that the decline in the overall mortality rate has not been stable over the total study period. It has continued to decline during the crisis period but at a slower pace. This is more evident for females than it is for males. Figure A1 in the Appendix presents the overall mortality rates for all 13 regions of Greece, showing that a similar pattern is observed across the country.

Regarding the cause-specific mortality rates examined in Figure 1, we observe that deaths from cardiovascular diseases continue to fall but also to a lesser extent, while deaths due to vehicular accidents, cancer, respiratory diseases, pregnancy-related conditions and infectious diseases have declined faster during the crisis. On the other hand, deaths from suicides, homicides, mental disorders, and nervous system and digestive diseases have followed an upward trend during this turbulent period in the Greek economy. Deaths by adverse events during medical treatment also show a sharp increase during the financial crisis.

[Insert Figure 1 here]

Using equation 1, the results presented in Table 2 confirm what Figure 1 shows graphically—that the overall mortality rate has continued to decline during the crisis period but at a slower pace (-0·1270 vs. -0·0647). The trend difference is statistically significant (0·0622, $p<0·001$). For both male and female mortality, the differences in trends are statistically significant and more prominent for female (0·0396, $p<0·01$ for males and 0·0870, $p<0·001$ for females).

The decline in the mortality rate from circulatory diseases-- the most common cause of death in Greece throughout the study period-- slowed. Conversely, deaths due to vehicular accidents and cancer have been on a steeper downward trend during the crisis. Deaths from suicides and from nervous system diseases have followed a small but positive and statistically significant trend since the onset of the crisis. Regarding deaths from homicides, the graphically observed upward trend in Figure 2 is not statistically different from zero either before or during the crisis. Finally, adverse events during medical treatment followed a downward slope before the crisis (-0·0005, $p<0·01$), while, during the crisis, there has been a significant increase (0·0015, $p<0·001$).

With the exceptions of homicides, cancer and pregnancy-related deaths, changes in trends for all other causes are statistically significant ($p<0.05$).

[Insert Table 2 here]

Age and gender differentiation

Table 3 presents results on the changes in mortality trends before and during the crisis by age, gender and cause of death and allows us to examine which groups have experienced the most changes during the financial crisis.

[Insert Table 3 here]

When looking at overall mortality trends, we observe an interesting age differentiation. The change in trends seen in Table 3 is significantly negative among younger groups (20-34 years) while significantly positive among older categories (above 65 years). This means that the overall mortality rate for the younger population has declined faster during the crisis, while it has slowed down for the older population. This is consistent for both men and women. The most favourable change in mortality trends is seen in young men aged 20-34, with about half of the improvement seemingly related to the steeper decline in deaths due to vehicle accidents. Conversely, the elderly have experienced the most significant unfavourable change during the crisis, and more than half of that change seems to be related to a worsening death rate from circulatory causes, followed by a substantial contribution to worsening trends by respiratory deaths.

Deaths by adverse events during medical treatment show a significant increase for both males and females, mainly among the older age groups.

Discussion and Conclusions

Our findings contribute to the continuing debate on economic crises and health outcomes internationally(6,19-21) by focusing on Greece, the European country hit the hardest by the 2008 financial crisis. Our study shows that the crisis slowed the overall decline in mortality in Greece, differentially affected older age groups, and had varied effects by cause of death. For females, the

change in trend is almost twice as strong as it is for males, indicating that women may have carried a bigger burden of the crisis. The international evidence on gender and mortality during crises is not conclusive,(15,22-23) but our findings are consistent with recent evidence showing that self-assessed health has deteriorated more for women than for men during the crisis in Greece.(24) We also find that older age groups have experienced more negative changes in overall mortality than the younger population, who have even seen some improvements in mortality trends during the crisis, due in good part to reduced mortality from traffic accidents. The negative changes among the elderly are seen mainly in the worsening trends in circulatory and digestive system diseases. There are many potential explanations for this pattern, including an impact from considerable reductions in pensions for those above age 65, or a decline in health care facilities and resources (both preventive and therapeutic) affecting primarily the most vulnerable—i.e., the elderly. A recent study in England found that mortality rates among pensioners aged 85 and over increased, and this was associated with reductions in spending on income support.(25)

In line with previous evidence, our results show that deaths from suicide have followed a positive upward trend during the crisis, particularly among men.(12-14) Our results also show that deaths due to vehicular accidents have declined faster during the crisis, confirming previous speculations that individuals have reduced their car travel and switched to cheaper forms of transportation due to a steep increase of fuel price.(26) This favourable pattern is seen predominantly among young men but is also seen, to a lesser extent, among young women. Deaths from circulatory diseases, the most common causes of mortality in the study period, also have continued to decline, as previous evidence has shown(27) but, like overall mortality, more slowly. Cancer rates continue to decline, however, the changes observed, are not statistically significant. Of course, the impact of the crisis on lifestyle-related conditions, such as cancer and cardiovascular disease, is harder to capture, as it may take years before behavioural changes—some healthy and some not—affect outcomes. A recent report provided the first empirical evidence that the amount of smoking and alcohol consumption declined between 2009 and 2014.(28) Greece has had the highest rates of smoking in the world. With the beginning of the economic crisis, the number of cigarettes smoked per capita started to decline.(29) The proportion of smokers in the adult population was slower to diminish, except for the young where a decline was seen faster. There is also some evidence that a 2011 tax increase on cigarettes led to a decrease in cigarette consumption within a year of its implementation.(30) Changes in smoking habits may also explain the lower mortality rate due to respiratory diseases that we find, although it may long before these changes are fully reflected in mortality rates. There have been also reports that the economic crisis has been linked to resurgence of malaria in some parts of Greece and an increase in new HIV infections.(31) However, these changes would not be possible to capture in our analysis of mortality rates.

A finding that requires particular attention is the sharp increase in deaths by adverse events during medical treatment since the beginning of the crisis. This provides some novel evidence on the association between quality of health care and health outcomes, as this cause of death has not been well explored in the literature before. Previous studies from the US, argued that cyclical fluctuations in the quality of health care may explain cyclical movements in mortality, due to better health care professional being attracted during financially difficult periods, when the labour market softens.(32-33) Our results are in contrast with these studies, primarily because our findings do not support their thesis that mortality rates are pro-cyclical. The increase of deaths by adverse events we observe could be explained possibly by serious shortages of medical

staff and burnout among health workers in Greece that recent studies have highlighted.(34) The elderly seem to be the most susceptible and are most affected by this increase in that cause of death. An alternative explanation might be greater willingness to acknowledge medical errors as a cause of demise, but no such change has happened to our knowledge. Additional studies on financial crisis effects should verify this observation.

A question often asked is how many excess deaths has the crisis caused. This is extremely difficult to answer because, due to the nature of our data, causality cannot be assumed. Moreover, there is no guarantee that the trajectory of deaths rates would have continued unchanged, if the crisis had not happened. With these caveats in mind, one may still use the data that we derived on the slopes of change of age- and gender-adjusted mortality rates and translate these into absolute numbers of deaths per month. Comparing the expected values of the during-crisis versus extrapolated before-crisis fitted regressions (using the model specified in Equation 1; see Figure A2 of the appendix), one estimates that throughout the crisis period there were an extra 241 deaths per month and that there were per month an excess of 153 deaths from circulatory causes, 16 from nervous system diseases, 13 from digestive system diseases, 5 from medical errors, 4 from infectious diseases, 2 from suicides, and 2 from mental diseases, while there were 25 fewer deaths per month from vehicle accidents, 44 from cancer, and 33 from respiratory causes. Note that the reported average number of excess deaths from infectious diseases, despite the negative trend showed above, is due to higher extrapolated estimates during the first year of the crisis. The numbers presented in Table A2 in the appendix depend on extrapolations of the before-crisis patterns and thus should be seen with extreme caution, but they give a rough impression about the potential magnitude of the absolute magnitude of the effects. In all, they suggest that while some causes of death such as suicides and homicides have captured more attention both in the literature(35) and in mass media, changes in common causes of death such as circulatory diseases are likely to be more important contributors to the number of excess deaths during the recession. They also show, that the number of excess deaths was higher for women (142 excess deaths per month) than for men (104 excess deaths per month).

Our study is not without limitations. Its ecological nature means that the analysis is based on aggregate-level data and does not allow inferences to be made at an individual level. In addition, data on suicides are rather sensitive. Due to religious attitudes and the stigma surrounding suicide, some suicides may be misclassified on death certificates. There is no evidence, though, that this phenomenon has changed during the crisis period. In addition, although we weight our estimations with the regional population, we cannot explicitly control for migration fluctuations due to the lack of data. However, controlling for the region-specific fixed effects and for region-time interactions we can, to an extent, mitigate this problem. Also, the nature of the study does not allow us to disentangle the mechanisms that led to the results observed in our paper. We offer some explanations of why certain trends are observed, based on what previous evidence has shown, but we cannot identify definitive reasons behind these, and thus, claims of causation should be avoided.(36) Further research is needed to look at associations of mortality with macroeconomic indicators, such as unemployment, controlling for the impact of health insurance and social protection schemes, to better understand the drivers of the health effects of the crisis. Further analysis to consider lag effects and the use of appropriate control groups is left for future research.

Author Statements

Authors' contributions: IL and CS were involved in the initial conception of the study. All authors elaborated the study design. IL conducted the data analysis. IL, JI and CS were involved in the interpretation and discussion of results. All authors contributed to the writing of the manuscript, critically revised it and approved the final version.

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Tables and Figures

Table 1. Basic descriptive statistics of mortality rates by gender, age, cause of death and time period

	Total period (2001m1-2013m12)		Before crisis (2001m1-2008m8)		During crisis (2008m9-2013m12)		
Categories	Mean	Std.Dev.	Mean	Std.Dev.	Mean	Std.Dev	*t*-test
Overall	69·10	8·31	72·36	7·90	64·46	6·48	<0.0001
Males	73·61	9·04	76·94	8·63	68·85	7·31	<0.0001
Females	64·45	8·97	67·63	8·73	59·91	7·15	<0.0001
Age: ≤19 years	0·67	0·40	0·72	0·41	0·60	0·37	<0.0001
Age: 20-34 years	1·22	0·53	1·30	0·54	1·10	0·50	<0.0001
Age: 35-44 years	1·34	0·49	1·40	0·50	1·24	0·45	<0.0001
Age: 45-64 years	9·16	1·44	9·26	1·47	9·03	1·38	0·0028
Age: 65-74 years	14·43	2·50	15·28	2·41	13·23	2·11	<0.0001
Age: ≥75 years	42·28	5·69	44·38	5·57	39·26	4·33	<0.0001
Suicides	0·30	0·24	0·28	0·24	0·33	0·25	0·004
Homicides	0·09	0·13	0·08	0·13	0·10	0·13	0·08
Vehicles	1·24	0·63	1·40	0·64	1·01	0·54	<0.0001
Circulatory	31·44	6·43	34·63	5·75	26·88	4·23	<0.0001
Cancer	17·51	2·30	17·82	2·34	17·08	2·17	<0.0001
Nervous	0·92	0·42	0·87	0·40	1·00	0·44	<0.0001
Respiratory	5·61	1·56	5·44	1·50	5·85	1·62	<0.0001
Digestive	1·68	0·53	1·70	0·54	1·65	0·51	0·11
Pregnancy	0·003	0·034	0·003	0·028	0·004	0·042	0·24
Mental	0·09	0·12	0·09	0·13	0·07	0·12	0·0038
Infectious	0·59	0·43	0·54	0·38	0·66	0·49	<0.0001
Medical errors	0·07	0·11	0·06	0·10	0·07	0·12	0·015
Observations	2,028		1,196		832		

Data source: Hellenic Statistical Authority (ELSTAT).

Notes: Age-standardised figures per 100,000 inhabitants. Descriptive statistics are weighted by the square root of the regional population. The Student's *t*-test compares differences in means between the periods before and during the crisis (*p*-values are reported). The sample consists of 13 regions (NUTS-II) observed over 156 months (2,028 observations in total).

Figure 1. Mortality rates before and during the Greek economic crisis		
Overall	**Overall males**	**Overall females**
meantotaldeaths.eps	meanmaledeaths.eps	meanfemaledeaths.eps
Suicides	**Homicides**	**Vehicle accidents**
meantotalcause54.eps	meantotalcause55.eps	meantotalcause47.eps
Diseases of circulatory system	**Cancer**	**Diseases of nervous system**
meantotalcircular.eps	meantotalmalignant.eps	meantotalcause22.eps
Disease of respiratory system	**Disease of digestive system**	**Pregnancy and childbirth**
meantotalrespiratory.eps	meantotaldigestive.eps	meantotalpregnancy.eps
Mental disorders	**Infectious Diseases**	**Medical errors**
meantotalcause21.eps	meantotalinfectious.eps	meantotalcause49.eps
Data source: Hellenic Statistical Authority (ELSTAT). **Notes**: Age-standardized mean death rates per 100,000 inhabitants (and their 3-month moving averages). The dashed vertical line at 2008m9 indicates the onset of the recessionary period. Solid red lines represent the linear trends of mortality rates before and during the crisis. Shaded areas are the 95% confidence intervals for the linear trends. Regression results confirm that there are no discontinuities at the onset of the crisis.		

Table 2· Trends and levels of mortality rates before and during the crisis								
	Overall	**Males**	**Females**	**Suicides**	**Homicides**	**Traffic accidents**	**Circulatory**	**Cancer**
Pre-crisis trend	**-0·13[a] (-0·15 - - 0·1031)**	**-0·13[a] (-0·15 - - 0·1041)**	**-0·13[a] (-0·16 - - 0·099)**	0·00025 (-0·00018 - - 0·00064)	0·000069 (-0·00029 – 0·00043)	**-0·0019[c] (-0·0035 - - 0·00031)**	**-0·12[a] (-0·13 - - 0·098)**	-0·0055 (-0·013 – 0·0022)
During-crisis trend	**-0·065[a] (-0·080 - - 0·049)**	**-0·088[a] (-0·11 - - 0·067)**	**-0·041[a] (-0·059 - - 0·023)**	**0·0023[b] (0·0013 – 0·0034)**	0·00019 (-0·00083 – 0·0012)	**-0·0081[a] (-0·010 - - 0·0058)**	**-0·073[a] (-0·091 - - 0·054)**	-0·0073 (-0·019 – 0·0049)
Trend difference	**0·062[a] (0·041 – 0·083)**	**0·039[b] (0·013 – 0·066)**	**0·087[a] (0·064 – 0·11)**	**0·0021[b] (0·00092 – 0·0033)**	0·00012 (-0·0011 – 0·0014)	**-0·0062[a] (-0·0090 - - 0·0033)**	**0·043[a] (0·024 – 0·063)**	-0·0017 (-0·016 – 0·012)
	Nervous	**Respiratory**	**Digestive**	**Pregnancy**	**Mental**	**Infectious**	**Medical errors**	
Pre-crisis trend	-0·00046 (-0·0017 – 0·00076)	**0·010[a] (0·0056 – 0·015)**	-0·0020 (-0·0046 – 0·00053)	-0·000039 (-0·0001048 – 0·000027)	-0·00046 (-0·00096 – 0·000035)	**0·0016[c] (0·00015 – 0·0031)**	**-0·00048[b] (-0·00081 - - 0·00015)**	
During-crisis trend	**0·0032[a] (0·0017 – 0·0047)**	**-0·011[a] (-0·013 - - 0·079)**	**0·0026[c] (0·000043 – 0·0051)**	**-0·00099[c] (-0·00019 - - 0·000013)**	0·00027 (-0·00022 – 0·00076)	**-0·0025[b] (-0·0041 - - 0·00089)**	**0·0015[a] (0·00092 – 0·0021)**	
Trend difference	**0·0036[b] (0·0016 – 0·0056)**	**-0·021[a] (-0·025 - - 0·017)**	**0·0046[a] (0·0027 – 0·0065)**	-0·00059 (-0·00017 – 0·000054)	**0·00073[c] (0·000047 – 0·0014)**	**-0·0042[b] (-0·0066 - - 0·0017)**	**0·0020[a] (0·0012 – 0·0028)**	

Data source: Hellenic Statistical Authority (ELSTAT)

Notes: Ordinary Least Squares (OLS) regressions weighted with the regional population. All models control for regional fixed effects, time fixed effects and interactions between regions and time variables· The 95% CIs (in parentheses) are based on standard errors which have been corrected for clustering by region. All models are specified as in Equation 1. Age-standardized death rates per 100,000 inhabitants have been used as dependent variables. The sample consists of 13 regions (NUTS-II) observed over 156 months (2,028 observations in total). [a],[b] and [c] denote statistical significance at the 0·1%, 1% and 5% level, respectively.

Table 3· Changes in mortality rate trends by age, gender and cause of death						
	≤19 years	**20-34 years**	**35-44 years**	**45-64 years**	**65-74 years**	**≥75 years**
Overall	0·00074(-0·0011 – 0·0025)	**-0·0074(-0·0089 - -0·0059)[a]**	-0·0021(-0·0045 – 0·00028)	0·00073(-0·0054 – 0·0069)	**0·014(0·0072 – 0·02046)[b]**	**0·056 (0·042 – 0·071)[a]**
Males	0·0013(-0·00096 – 0·0035)	**-0·013(-0·016 - -0·0093)[a]**	**-0·0059(-0·0096 - -0·0023)[b]**	0·000046(-0·0085 – 0·0086)	0·010 (-0·0017 – 0·022)	**0·047(0·027 – 0·066)[a]**
Females	0·00016(-0·0018 – 0·0021)	**-0·0019(-0·0035 - -0·00031)[c]**	0·0018(-0·0013 – 0·0047)	0·0030(-0·0028 – 0·0089)	**0·015(0·0052 – 0·025)[b]**	**0·069(0·049 – 0·089)[a]**
Suicides males	0·00031(-0·000039 – 0·00067)	0·00031(-0·00066 – 0·0013)	0·00048(-0·0003012 - 0·0013)	**0·0011(-0·00000068 – 0·0022)[c]**	**0·00083(0·00026 – 0·0014)[b]**	-0·00019(-0·00072 – 0·00033)
Suicides females	0·000014(-0·00012 – 0·00014)	0·00028(-0·00018 – 0·00074)	**0·00029(0·000083 – 0·00050)[c]**	0·00039(-0·00014 – 0·00092)	0·00032(-0·0001027 – 0·00074)	0·00015(-0·000048 – 0·00034)
Homicides males	0·00010(-0·00024 – 0·00044)	-0·00031(-0·00098 – 0·00036)	-0·00021(-0·00067 – 0·00024)	0·00027(-0·00054 – 0·0011)	0·00013(-0·00029 – 0·00054)	0·000077(-0·00010 – 0·00026)
Homicides females	0·000095(-0·00011 – 0·00029)	-0·00011(-0·00036 – 0·00014)	-0·00019(-0·00053 – 0·00016)	0·000053(-0·00019 – 0·00031)	0·00019(-0·000084 – 0·00046)	0·00014(-0·000087 – 0·00037)
Vehicle Accident males	-0·0010(-0·0028 – 0·00071)	**-0·0065(-0·0085 - -0·0044)[a]**	**-0·0025(-0·004049 - -0·0096)[b]**	-0·0014(-0·0031 – 0·000305)	0·00062(-0·00023 – 0·0014)	-0·00058(-0·0013 – 0·00014)
Vehicle Accident females	-0·000056(-0·00062 – 0·0005046)	-0·00051(-0·0017 – 0·00066)	**0·00053(0·0001039 – 0·00095)[c]**	-0·00053(-0·0015 – 0·00046)	-0·00017(-0·00077 – 0·00042)	-0·00017(-0·00082 – 0·00047)
Circulatory system males	0·00012(-0·000078 – 0·00031)	**-0·0021(-0·0032 - -0·00097)[b]**	**-0·0019(-0·0037 - -0·000054)[c]**	0·0014(-0·0038 – 0·0066)	0·0065(-0·0028 – 0·016)	**0·027(0·016 – 0·039)[a]**
Circulatory system females	**0·00014(0·0000403 – 0·00023)[b]**	-0·00030(-0·0011 – 0·00045)	-0·000056(-0·0014 – 0·0013)	0·0010(-0·0012 – 0·0033)	**0·012(0·0062 – 0·018)[b]**	**0·043(0·023 – 0·062)[a]**
Cancer males	-0·000036(-0·00069 – 0·00061)	0·00024(-0·00092 – 0·0014)	0·00011(-0·0016 – 0·0018)	0·0019(-0·0052 – 0·0089)	0·0021(-0·0072 – 0·011)	-0·0062(-0·017 – 0·0049)
Cancer females	-0·00016(-0·00066 – 0·00035)	-0·00046(-0·0011 – 0·00021)	**0·0017(0·000047 – 0·0034)[c]**	0·0031(-0·00049 – 0·0067)	0·0017(-0·0036 – 0·0071)	-0·0065(-0·014 – 0·00069)
Nervous males	0·000074(-0·00029 – 0·00044)	0·00055(-0·000062 – 0·0012)	**0·00065(0·00013 – 0·0012)[c]**	0·00078(-0·00083 – 0·0024)	0·000054(-0·00085 – 0·00096)	**0·0015(0·000078 – 0·0029)[c]**
Nervous females	0·00011(-0·00033 – 0·00055)	-0·00022(-0·00055 – 0·00012)	0·00024(-0·00023 – 0·00071)	0·00079(-0·000081 – 0·0017)	**0·0014(0·00017 – 0·0026)[c]**	0·0014(0·00017 – 0·0026)
Respiratory system males	-0·00021(-0·00093 – 0·00051)	-0·00030(-0·00097 – 0·00037)	-0·00039(-0·00087 – 0·00010)	**-0·0049(-0·0066 - -0·0032)[a]**	**-0·0081(-0·013 - -0·0035)[b]**	**-0·0083(-0·013 - -0·0039)[b]**
Respiratory system females	-0·00040(-0·00084 – 0·000038)	-0·000050(-0·00048 – 0·00038)	0·000012(-0·00039 – 0·00042)	**-0·0025(-0·0039 - -0·001032)[b]**	**-0·0025(-0·0043 - -0·00059)[c]**	**-0·014(-0·017 - -0·01045)[a]**
Digestive system males	-0·000017(-0·00023 – 0·00019)	-0·00028(-0·00084 – 0·00029)	-0·00050(-0·0014 – 0·00041)	0·00056(-0·0013 – 0·0024)	0·00061(-0·00098 – 0·0022)	**0·0031(0·0012 – 0·0049)[b]**
Digestive system females	-0·00015(-0·00034 – 0·000050)	0·000012(-0·00032 – 0·00035)	-0·00021(-0·00058 – 0·00016)	0·00037(-0·00073 – 0·0015)	**0·0012(0·000075 – 0·0023)[c]**	**0·0048(0·0032 – 0·0064)[a]**
Pregnancy and childbirth	-0·000057(-0·00017 – 0·000054)	-0·000062(-0·00018 – 0·000053)	-0·000055(-0·00017 – 0·000056)	-	-	-

Mental disorders males	0·00000041(-0·00000054 – 0·000014)	-0·000080(-0·00018 – 0·000023)	-0·00014(-0·00036 – 0·000082)	-0·000057(-0·00052 – 0·0004028)	-0·000029(-0·00019 – 0·00014)	**0·00038(0·00014 – 0·00062)[b]**
Mental disorders females	-0·00000023(-0·00000065 – 0·00000018)	0·000053(-0·000081 – 0·00019)	-0·000083(-0·00024 – 0·000075)	-0·000076(-0·00019 – 0·000045)	0·00042(-0·000067 – 0·00091)	**0·0011(0·00033 – 0·0019)[b]**
Infectious diseases males	0·00020(-0·000028 – 0·00042)	-0·0000000080(-0·00024 – 0·00024)	-0·00021(-0·00051 – 0·000097)	-0·00065(-0·0016 – 0·00029)	-0·00077(-0·0019 – 0·00035)	-0·0020(-0·0042 – 0·00012)
Infectious diseases females	-0·000041(-0·00023 – 0·00014)	-0·00083(-0·00024 – 0·000074)	0·000021(-0·00018 – 0·00022)	-0·00035(-0·00086 – 0·00016)	**-0·0013(-0·0024 - - 0·000094)[c]**	**-0·0031(-0·0055 - - 0·00071)[c]**
Medical errors males	-0·000027(-0·00011 – 0·000059)	0·000035(-0·00013 – 0·00020)	0·00052(-0·00071 – 0·00018)	0·00037(-0·00013 – 0·00087)	**0·00099(0·00034 – 0·0016)[b]**	**0·00065(0·00031 – 0·00098)[b]**
Medical errors females	-0·000028(-0·000094 – 0·000039)	0·000099(-0·000076 – 0·00027)	-0·000055(-0·00022 – 0·00011)	**0·00062(0·00041 – 0·00084)[a]**	**0·00077(0·00042 – 0·0011)[a]**	**0·00048(0·00033 – 0·00063)[a]**

Data source: Hellenic Statistical Authority (ELSTAT)

Notes: Ordinary Least Squares (OLS) regressions weighted with the square root of the regional population. The 95% CIs (in parentheses) are based on standard errors which have been corrected for clustering by region.. All models are specified as in Equation 1. Age-standardized death rates per 100,000 inhabitants have been used as dependent variables. The sample consists of 13 regions (NUTS-II) observed over 156 months (2,028 observations in total). [a],[b] and [c] denote statistical significance at the 0·1%, 1% and 5% level, respectively.

Appendix

Table A1· Definitions of cause-specific mortality

Cause	Description	ICD-10 code
Infectious	Infectious and parasitic diseases	ICD01-ICD07
Mental	Mental and behavioural disorders	ICD21
Nervous	Diseases of the nervous system	ICD22
Respiratory	Diseases of the respiratory system	ICD31-32
Digestive	Diseases of the digestive system	ICD33-34
Pregnancy	Pregnancy, childbirth and the puerperium	ICD38-41
Medical errors	Adverse events during medical treatment	ICD49
Vehicles	Accidents by vehicles	ICD47
Suicides	Suicide and intentional self-harm	ICD54
Homicides	Homicide	ICD55
Circulatory	Diseases of the circulatory system	ICD25-ICD30
Cancer	Malignant neoplasms	ICD08-ICD14, ICD16-ICD17

Table A2· Estimated number of excess deaths each month during the economic recession in Greece, 2008m9-2013m12

	During-crisis expected monthly mortality rate per 100,000 inhabitants (95% CI) (1)	Before-crisis extrapolated monthly mortality rate per 100,000 inhabitants (95% CI) (2)	Mean difference: (1) - (2) (95% CI) (3)	Mean number of excess deaths per month: 2008m9-2013m12 (95% CI) (4)
Total deaths	64.038 (63.691 to 64.386)	61.860 (61.446 to 62.276)	2.178[a] (1.968 to 2.388)	241.5 (218.2 to 264.7)
Males	68.229 (67.853 to 68.604)	66.308 (65.881 to 66.735)	1.921[a] (1.655 to 2.187)	104.4 (89.9 to 118.8)
Females	59.513 (59.145 to 59.881)	56.995 (56.544 to 57.446)	2.518[a] (2.265 to 2.771)	142.3 (128.0 to 156.7)
Suicides	0.336 (0.326 to 0.345)	0.316 (0.308 to 0.324)	0.019[b] (0.009 to 0.029)	2.1 (1.0 to 3.3)
Homicides	0.090 (0.086 to 0.095)	0.084 (0.079 to 0.088)	0.006[c] (0.001 to 0.012)	0.7 (0.1 to 1.3)
Vehicles	1.034 (1.010 to 1.059)	1.258 (1.231 to 1.285)	-0.224[a] (-0.249 to -0.198)	-24.8 (-27.6 to -22.0)
Circulatory	26.739 (26.493 to 26.985)	25.357 (25.050 to 25.663)	1.382[a] (1.243 to 1.522)	153.2 (137.8 to 168.7)
Cancer	16.694 (16.589 to 16.801)	17.093 (16.991 to 17.196)	-0.399[a] (-0.479 to -0.319)	-44.2 (-53.1 to -35.4)
Nervous	0.974 (0.957 to 0.991)	0.824 (0.810 to 0.838)	0.150[a] (0.132 to 0.168)	16.6 (14.6 to 18.6)
Respiratory	5.749 (5.662 to 5.835)	6.046 (5.977 to 6.115)	-0.297[a] (-0.356 to -0.238)	-33.0 (-39.5 to -26.4)
Digestive	1.623 (1.602 to 1.644)	1.502 (1.483 to 1.521)	0.121[a] (0.098 to 0.144)	13.4 (10.9 to 16.0)
Pregnancy	0.005 (0.003 to 0.006)	-0.001 (-0.002 to -0.000)	0.006[a] (0.004 to 0.007)	0.6 (0.4 to 0.8)
Mental	0.076 (0.072 to 0.079)	0.058 (0.054 to 0.061)	0.018[a] (0.013 to 0.023)	2.0 (1.4 to 2.6)
Infectious	0.710 (0.687 to 0.734)	0.678 (0.662 to 0.694)	0.033[c] (0.015 to 0.051)	3.6 (1.6 to 5.6)
Medical errors	0.069 (0.064 to 0.073)	0.020 (0.017 to 0.023)	0.049[a] (0.043 to 0.054)	5.4 (4.8 to 6.0)

Data source: Hellenic Statistical Authority (EL.STAT)

Notes: Figures in column (1) are the mean fitted values from the estimation of Equation 1 for the crisis period (2008m9-2013m12). Figures in column (2) are the extrapolated fitted values from the estimation of Equation 1 for the period before the crisis (2001m1-2008m8). A Satterthwaite's *t*-test examines whether their difference, in column (3), is statistically significant. In column (4) the difference in the mortality rates is converted to number of excess (or fewer) deaths (based on a total population of approximately 11 million during the crisis period). [a],[b] and [c] denote statistical significance at the 0·1%, 1% and 5% level, respectively.

Figure A1· Standardized total mortality rate by region
byregion_monthly.eps
Data source: Hellenic Statistical Authority (ELSTAT). **Notes:** The dashed vertical line at 2008m9 indicates the onset of the recessionary period.

Figure A2: Observed and extrapolated mean mortality rates
projection_totaldeaths.eps
Data source: Hellenic Statistical Authority (EL.STAT) **Notes:** Age-standardized mean death rates per 100,000 inhabitants. The dashed vertical line at 2008m9 indicates the onset of the recessionary period. Solid red lines represent the linear trend of mortality rates before and during the crisis. The dashed red line is the projection of the pre-crisis linear trend into the recessionary period. Blue line represent the mean extrapolated death rate from a before-crisis fitted regression.