Total and cause-specific mortality before and after the onset of the Greek economic crisis: an interrupted time-series analysis

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Summary

Background Greece was one of the countries hit the hardest by the 2008 financial crisis in Europe. Yet, evidence on the effect of the crisis on total and cause-specific mortality remains unclear. We explored whether the economic crisis affected the trend of overall and cause-specific mortality rates.

Methods We used regional panel data from the Hellenic Statistical Authority to assess mortality trends by age, sex, region, and cause in Greece between January, 2001, and December, 2013. We used Eurostat data to calculate monthly age-standardised mortality rates per 100 000 inhabitants for each region. Data were divided into two subperiods: before the crisis (January, 2001, to August, 2008) and after the onset of the crisis (September, 2008, to December, 2013). We tested for changes in the slope of mortality by doing an interrupted time-series analysis.

Findings Overall mortality continued to decline after the onset of the financial crisis (–0·065, 95% CI –0·080 to –0·049), but at a slower pace than before the crisis (–0·13, –0·15 to –0·10; trend difference 0·062, 95% CI 0·041 to 0·083; p<0·0001). The trend difference was more evident for females (0·087, 95% CI 0·064–0·11; p<0·0001) than for males (0·040, 0·013–0·066; p=0·007). Those aged at least 75 years experienced more negative effects (trend difference 0·056, 95% CI 0·042 to 0·071; p<0·0001) than did those aged 20–34 years, in whom mortality trends improved (–0·0074, –0·0089 to –0·0059; p<0·0001). Deaths by diseases of the circulatory system declined more slowly after the onset of compared with before the crisis (trend difference 0·043, 95% CI 0·024 to 0·063; p<0·0001), whereas deaths from vehicular accidents declined faster (–0·0062, –0·0090 to –0·0033; p<0·0001), most prominently among men aged 20–34 years (–0·0065, –0·0085 to –0·0044; p<0·0001). Conversely, deaths from suicides (trend difference 0·0021, 95% CI 0·00092–0·0033; p=0·002), diseases of the nervous system (0·0036, 0·0016–0·0056; p=0·002), and mental health problems (0·00073, 0·000047–0·0014 p=0·038) increased after the onset of the crisis. Also, deaths due to adverse events during medical treatment increased significantly after the onset of the crisis (trend difference 0·0020, 95% CI 0·0012–0·0028; p<0·0001). By comparing the expected values of the period after the onset of the crisis with extrapolated values based on the period before the crisis, we estimate that an extra 242 deaths per month occurred after the onset of the crisis.

Interpretation Mortality trends have been interrupted after the onset of compared with before the crisis, but changes vary by age, sex, and cause of death. The increase in deaths due to adverse events during medical treatment might reflect the effects of deterioration in quality of care during economic recessions.

Funding None.

Lancet Public Health 2016; 1: e56–65

Published Online November 4, 2016 http://dx.doi.org/10.1016/S2468-2667(16)30018-4

This online publication has been corrected. The corrected version first appeared at thelancet.com/public-health on November 28, 2016

See **Comment** page e40

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Introduction

Since the global financial crisis began in 2008, Greece has been experiencing one of the most severe financial crises in its recent history. The crisis has had a direct effect on the Greek health system, which faced financial difficulties and structural problems long before the crisis hit.[1] Many health reforms, including the reduction in pharmaceutical expenditures and the structural reform of social health insurance funds, had been on the agenda for over a decade, but had never been implemented because of an absence of political will and the resistance of key stakeholders.[2] However, when these reforms were finally enacted, the Greek economy was already deteriorating severely. 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 highest among young groups (particularly those aged 15–24 years),[4] making financing of the health system, which depends largely on social health insurance, even harder, and raising concerns regarding the reduction of health coverage among those without a job. Additionally, the reforms were focused, by and large, on horizontal cost-cutting measures aimed at providing immediate effects and did not include any long-term considerations of the effect on equity of access and quality of care. A recent study[5] revealed that the adverse economic environment caused a substantial increase in unmet health needs in Greece.

Research in context

Evidence before this study

JPAI and CS did a systematic literature review exploring the empirical evidence of the effect of the European financial crisis on health outcomes. We searched PubMed, ISI Web of Knowledge, EBSCOhost, Scopus, and Google Scholar. We hand-searched *The Lancet*, *European Journal of Public Health*, *Health Policy*, *Social Science and Medicine*, *BMJ*, *PLoS One*, and *BMJ Open*. And we reviewed several relevant organisations' websites, including WHO, Organisation for Economic Co-operation and Development, European Observatory on Health Systems and Policies, and UNICEF. We used the following search terms: "financial crisis", "economic crisis", "recession", and "austerity", in conjunction with "health", "health outcomes", "healthcare", and "Europe". We included empirical, quantitative papers published from January, 2008, to Jan 15, 2016. 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. Of the 41 studies reviewed, two assessed mortality trends in Europe: one focused on Spain and one compared trends in Greece with those in Ireland and Finland. Both studies analysed data until 2011, which increases the risk of bias because few data were from the financial crisis period. 16 studies have investigated suicides across Europe, but evidence on other cause-specific mortality trends is scarce.

Added value of this study

We have added information to the ongoing international debate about the effect of economic crises on health outcomes by systematically analysing mortality rates in Greece, the country hit the hardest by the financial crisis in Europe. We analysed data on deaths by adverse events during medical treatment, which have not been explored in other similar contexts previously. Methodologically, rather than expecting immediate jumps in mortality rates at the start of the crisis and instead of comparing period-specific means, our model, using regional panel data, allowed us to test how health outcomes were affected as the crisis deepened.

Implications of all the available evidence

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

Evidence on the effect of economic crises on health is mixed. On the one hand, during difficult economic periods, reductions in health-care spending are expected to compromise the quality of services provided, leading to a deterioration of health outcomes. Additionally, reductions in household budgets, as a result of unemployment or reductions in pensions and wages, decrease individuals' ability to pay for health care, again leading potentially to a deterioration of health outcomes. This deterioration of health outcomes seems more evident in countries with weaker social protection schemes.[6] On the other hand, during economic recessions, increases in tobacco and alcohol taxation might lead individuals to adopt healthier lifestyles, whereas traffic deaths tend to decrease as unemployment increases because of a drop in the use of cars.[7] Also, how lifestyle behaviours change during recessions is not clear. During the economic recession of 2008–09 in the USA, alcohol use declined overall, but frequent binge drinking increased, affecting mainly the young and unemployed.[8]

For more on **ELSTAT** see http://www.statistics.gr/en

In Greece, concerns about the effect of the crisis on health outcomes were inevitable, and Kentikelenis and colleagues[9] referred to it as a modern Greek tragedy. Yet, the empirical evidence so far has been inconclusive. Vlachadis and colleagues[10] showed a rising trend in total deaths among those older than 55 years in Greece in 2011–12, whereas Tapia Granados and Rodriguez[11] compared data from Greece with those from Iceland and Finland and argued that, after 2007, total deaths in Greece for most age groups continued to fall at the same rate as in previous years. Further evidence suggests that suicides increased during the economic crises in Greece,[12,13] with the association being strongest among men of working age.[13,14] Little is known about other causes of mortality during the Greek economic crisis.

We aimed to explore whether the Greek financial crisis has affected the trend of overall and cause-specific mortality rates in 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, we used an interrupted time-series estimator to test how health outcomes were affected as the crisis deepened.

Methods

Data sources and descriptive analysis

We used data from the Hellenic Statistical Authority (ELSTAT), which contains monthly information regarding the number of deaths in Greece during the period January, 2001, to December, 2013, by age, sex, region, and cause, to assess mortality trends during the financial crisis in Greece. Specifically, in ELSTAT, the total numbers of deaths are provided by age category in 5-year bands and by regions classified according to the Nomenclature of Territorial Units for Statistics 2 (NUTS 2; 13 administrative regions). The total number of deaths is further disaggregated to 56 causes according to the two-digit International Classification of Diseases

classification. We focused on overall mortality and on the main causes of death in Greece, including deaths from circulatory system diseases, cancer, respiratory disorders, nervous system diseases, and digestive diseases, as well as the main causes discussed in published work on economic crises, including deaths from vehicular accidents, suicides, homicides, mental health problems, infectious diseases, and disorders related to pregnancy and childbirth.[6,9] We also focused on causes that we hypothesised might be linked to the deterioration of health care during a recession, such as deaths due to adverse events during medical treatment (appendix p 1). Using publicly available Eurostat data on regional populations, we calculated the monthly age-standardised mortality rates per 100 000 inhabitants for each region. This study did not require ethical approval.

Empirical strategy

We used panel data containing sequential information before compared with after the onset of the crisis for every Greek region.[6,15] We divided our sample into two distinct subperiods: before the crisis (January, 2001, to August, 2008) and after the onset of the crisis (September, 2008, to December, 2013), because previous evidence showed that unemployment started increasing steeply during the third quarter of 2008.[16] We used all the available information, and so data were not distributed equally before and after the onset of the crisis.

Despite the severity of the crisis, we did not expect a sharp change in mortality rates at the beginning of the recession. Rather, we assumed that the adjustment of health outcomes, if any, should be more gradual—ie, as the crisis deepens. Therefore, we tested whether mortality trends changed after the onset of compared with before the crisis. Moreover, because every region was exposed to the financial crisis, there were no distinct treated and control regions to undertake a difference-in-differences analysis. Instead, we tested for changes in the slope of mortality by doing a single-group interrupted time-series analysis. To do so, we used the following equation:

$$M_{rt}^{c} = \alpha_0 + \alpha_1 T + \alpha_2 \mathbf{1}\{T \geq \tilde{T}\} + \alpha_3 (T - \tilde{T}) \times \mathbf{1}\{T \geq \tilde{T}\} + bX_{rt} + e_{rt}$$

where M_{rt}^{c} is the age-standardised mortality rate for cause c in region r during month t; T is a running counter of months since the beginning of the sample; $\tilde{T}$ is a breakpoint specified in the first month of the crisis period (September, 2008); and X_{rt} is a vector containing regional fixed effects to account for permanent disparities across regions and interactions between regional and time indicators to control for seasonality, region-specific financial shocks, and unobserved factors that might have affected regional health outcomes (eg, lifestyle habits and pressure from unrecorded migration). According to this model specification, α_0 is the mean outcome level at the beginning of the study period; α_1 is the slope of the mortality rate before the crisis; α_2 shows whether the mean mortality level changed immediately after the onset of the crisis; and α_3 is the difference in mortality rate slopes before compared with after the onset of the crisis. Hence, $\alpha_1 + \alpha_3$ is the mortality trend after the onset of the crisis. Since, by design, there are no comparable control regions in this single-group interrupted time-series analysis, the mortality trend before the crisis projected into the second period (ie, after September, 2008) is the counterfactual outcome that would have been observed if the crisis had not occurred.[17] We estimated the models in Stata version 14.1 via ordinary least-squares regression. All descriptive statistics and models were weighted by the square root of the regional population. Findings from a Wooldridge test[18] suggested the presence of within-region correlation; therefore, the reported 95% CIs are based on SEs that are corrected for clustering by region to account for omitted factors that evolve slowly over time and are not completely controlled for by the region-specific fixed effects. 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 is likely to vary substantially across sexes, age groups, and diseases. Moreover, to check for outliers or non-linearities in the relationship between mortality and time that could affect our results, we did some kernel-weighted local polynomial regressions.

Finally, we aimed to get a rough estimate of the excess deaths that occurred after the onset of the crisis. To do so, we compared the expected mortality rate per 100 000 inhabitants for the period after the onset of the crisis with extrapolated values based on fitted regressions for the period before the crisis using the aforementioned equation. We multiplied those differences by the mean population of Greece during the crisis period using the total, sex-specific, and age-specific population data from Eurostat. We acknowledge that these estimates should be interpreted with caution, because our study cannot claim causality. p values less than 0·05 were judged to be statistically significant.

See **Online** for appendix

For more on **Eurostat** see http://ec.europa.eu/eurostat

Role of the funding source

There was no funding source for this study. IL and CS had full access to all the data in the study and all authors had final responsibility for the decision to submit for publication.

Results

We included data from 13 regions (NUTS 2) over 156 months, giving 2028 observations in total. Although data were not distributed equally before and after the onset of the crisis, visual inspection of the series suggested that mortality trends had not changed substantially before the crisis. Moreover, the results obtained were similar when the analysis was done on a

truncated sample in which both the periods were of the same duration (data not shown).

Age-standardised mean mortality rates decreased significantly for both sexes and across all age groups after the onset of the crisis compared with the period before (table 1). With the exception of deaths from homicide, digestive diseases, and disorders related to pregnancy and childbirth, for all other causes the changes in mean age-standardised death rates, whether positive or negative, were statistically significant.

Although there was probably a lag period between the onset of the recession and changes in mortality trends, a visual inspection of the data suggested that a gradual, continuous effect, modelled by a change in the mortality rate slope after the beginning of the recession, is a reasonable approximation. Kernel-weighted local polynomial regressions suggested that the linear approximation fitted the data quite well (data not shown). The figure provides some graphical evidence that the decline in the overall mortality rate was not stable over the total study period. The mortality rate continued to decline after the onset of the crisis period, but at a slower pace than before the recession. This reduction in decline was more evident for females than for males. The appendix (p 3) presents the overall mortality rates for all 13 regions of Greece, showing a similar pattern across the country.

Regarding cause-specific mortality, we found that, compared with before the crisis, deaths from circulatory diseases continued to fall, but to a lesser extent, whereas deaths due to vehicular accidents, cancer, respiratory diseases, disorders related to pregnancy and childbirth, and infectious diseases declined faster after the onset of the crisis (figure). Conversely, mean death rates from suicides, homicides, mental health problems, nervous system diseases, and digestive diseases increased after the onset of compared with before the financial crisis in Greece. Deaths from adverse events during medical treatment also increased sharply after the onset of the financial crisis.

Using the aforementioned equation, the results presented in table 2 confirm what the figure shows graphically—that overall mortality continued to decline after the onset of the crisis, but at a slower pace than

	Total period (January, 2001, to December, 2013; n=2028)	Before the crisis (January, 2001, to August, 2008; n=1196)	After the onset of the crisis (September, 2008, to December, 2013; n=832)	p value*
Overall	69·10 (8·31)	72·36 (7·90)	64·46 (6·48)	<0·0001
Sex				
Male	73·61 (9·04)	76·94 (8·63)	68·85 (7·31)	<0·0001
Female	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
20–34 years	1·22 (0·53)	1·30 (0·54)	1·10 (0·50)	<0·0001
35–44 years	1·34 (0·49)	1·40 (0·50)	1·24 (0·45)	<0·0001
45–64 years	9·16 (1·44)	9·26 (1·47)	9·03 (1·38)	0·0028
65–74 years	14·43 (2·50)	15·28 (2·41)	13·23 (2·11)	<0·0001
≥75 years	42·28 (5·69)	44·38 (5·57)	39·26 (4·33)	<0·0001
Cause of death				
Suicide	0·30 (0·24)	0·28 (0·24)	0·33 (0·25)	0·004
Homicide	0·09 (0·13)	0·08 (0·13)	0·10 (0·13)	0·08
Vehicular accident	1·24 (0·63)	1·40 (0·64)	1·01 (0·54)	<0·0001
Circulatory system disease	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 system disease	0·92 (0·42)	0·87 (0·40)	1·00 (0·44)	<0·0001
Respiratory disorder	5·61 (1·56)	5·44 (1·50)	5·85 (1·62)	<0·0001
Digestive disease	1·68 (0·53)	1·70 (0·54)	1·65 (0·51)	0·11
Disorders related to pregnancy and childbirth	0·003 (0·034)	0·003 (0·028)	0·004 (0·042)	0·24
Mental health problem	0·09 (0·12)	0·09 (0·13)	0·07 (0·12)	0·0038
Infectious disease	0·59 (0·43)	0·54 (0·38)	0·66 (0·49)	<0·0001
Adverse events during medical treatment	0·07 (0·11)	0·06 (0·10)	0·07 (0·12)	0·015

Data are mean age-standardised mortality rates per 100 000 inhabitants (SD), unless otherwise specified. *Student's *t* test comparing differences in means between the periods before and after the onset of the crisis.

Table 1: **Basic descriptive statistics of mortality rates by sex, age, cause of death, and time period**

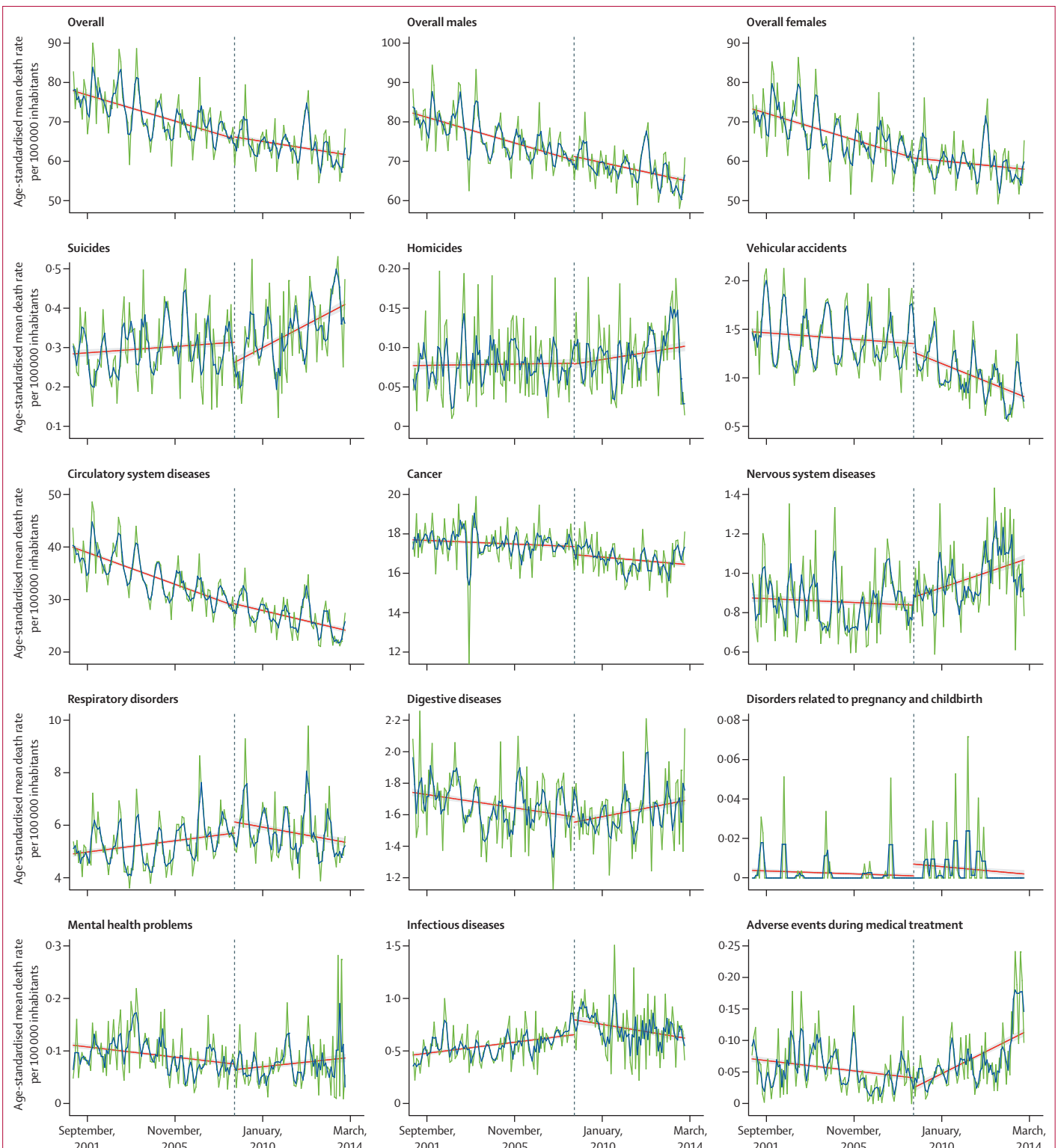

Figure: **Mortality rates over the study period**
Age-standardised mean death rates per 100 000 inhabitants (green lines) and their 3-month moving means (blue lines) are shown. The dashed vertical line at September, 2008, shows the onset of the recession. Solid red lines represent the linear trends of mortality rates. Shaded areas are 95% CIs for the linear trends.

	Trend before the crisis (95% CI)	Trend after the onset of the crisis (95% CI)	Trend difference (95% CI)
Overall	–0·13 (–0·15 to –0·10)*	–0·065 (–0·080 to –0·049)*	0·062 (0·041 to 0·083)*
Sex			
Male	–0·13 (–0·15 to –0·10)*	–0·088 (–0·11 to –0·067)*	0·040 (0·013 to 0·066)†
Female	–0·13 (–0·16 to –0·099)*	–0·041 (–0·059 to –0·023)*	0·087 (0·064 to 0·11)*
Cause of death			
Suicide	0·00025 (–0·00018 to 0·00064)	0·0023 (0·0013 to 0·0034)†	0·0021 (0·00092 to 0·0033)†
Homicide	0·000069 (–0·00029 to 0·00043)	0·00019 (–0·00083 to 0·0012)	0·00012 (–0·0011 to 0·0014)
Vehicular accident	–0·0019 (–0·0035 to –0·00031)‡	–0·0081 (–0·010 to –0·0058)*	–0·0062 (–0·0090 to –0·0033)*
Circulatory system disease	–0·12 (–0·13 to –0·098)*	–0·073 (–0·091 to –0·054)*	0·043 (0·024 to 0·063)*
Cancer	–0·0055 (–0·013 to 0·0022)	–0·0073 (–0·019 to 0·0049)	–0·0017 (–0·016 to 0·012)
Nervous system disease	–0·00046 (–0·0017 to 0·00076)	0·0032 (0·0017 to 0·0047)*	0·0036 (0·0016 to 0·0056)†
Respiratory disorder	0·010 (0·0056 to 0·015)*	–0·011 (–0·013 to –0·079)*	–0·021 (–0·025 to –0·017)*
Digestive disease	–0·0020 (–0·0046 to 0·00053)	0·0026 (0·000043 to 0·0051)‡	0·0046 (0·0027 to 0·0065)*
Disorders related to pregnancy and childbirth	–0·000039 (–0·00010 to 0·000027)	–0·00099 (–0·00019 to –0·000013)‡	–0·00059 (–0·00017 to 0·000054)
Mental health problem	–0·00046 (–0·00096 to 0·000035)	0·00027 (–0·00022 to 0·00076)	0·00073 (0·000047 to 0·0014)‡
Infectious disease	0·0016 (0·00015 to 0·0031)‡	–0·0025 (–0·0041 to –0·00089)†	–0·0042 (–0·0066 to –0·0017)†
Adverse events during medical treatment	–0·00048 (–0·00081 to –0·00015)†	0·0015 (0·00092 to 0·0021)*	0·0020 (0·0012 to 0·0028)*

Data are ordinary least-squares regressions weighted by the regional population. All models control for regional fixed effects, time fixed effects, and interactions between regions and time variables. 95% CIs are based on SEs that were corrected for clustering by region. Age-standardised death rates per 100 000 inhabitants were used as dependent variables. *p<0·001. †p<0·01. ‡p=0·040.

Table 2: **Mortality rate trends before and after the onset of the crisis**

before the crisis (–0·13 *vs* –0·065; trend difference 0·062, 95% CI 0·041–0·083; p<0·0001). The difference in mortality trends was significant in both females (0·087; p<0·0001) and males (0·040; p=0·007).

The decline in the mortality rate from circulatory diseases—the most common cause of death in Greece throughout the study period—slowed after the onset of compared with before the financial crisis. Conversely, deaths due to vehicular accidents decreased to a greater extent after the onset of compared with before the crisis. Deaths from suicides and from nervous system diseases increased slightly but significantly after the onset of compared with before the crisis. Regarding deaths from homicides, the graphically observed increase in the figure was not significantly different from zero either before or after the onset of the crisis. Finally, adverse events during medical treatment followed a downward slope before the crisis (–0·00048, 95% CI –0·00081 to –0·00015; p=0·008), whereas after the onset of the crisis, they increased significantly (0·0015, 0·00092 to 0·0021; p<0·0001). With the exceptions of homicides, cancer, and disorders related to pregnancy and childbirth, changes in trends for all other causes were statistically significant (all p<0·05).

Table 3 shows the changes in mortality trends before compared with after the onset of the crisis by age, sex, and cause of death. When looking at overall mortality trends, we noted that the change in trends was significantly negative among the 20–34 years group, but significantly positive among older categories (≥65 years; table 3). Thus, compared with before the financial crisis, overall mortality for the younger population had declined faster after the onset of the crisis, whereas it had slowed for the older population. The most favourable change in mortality trends occurred in young men aged 20–34 years (trend difference –0·013, 95% CI –0·016 to –0·0093; p<0·0001), with about half of the improvement seemingly related to the steeper decline in deaths due to vehicular accidents (–0·0065, –0·0085 to –0·0044; p<0·0001). Conversely, people older than 65 years experienced the most substantial increase in death rate after the onset of the crisis, and more than half of that change seemed to be related to an increased death rate from circulatory causes, followed by a substantial contribution to worsening trends by digestive diseases. Deaths by adverse events during medical treatment increased significantly for both males and females in those aged 65 years and older.

Comparing the expected values of the period after onset of the crisis with extrapolated values based on fitted regressions for the period before the crisis (using the model specified in the aforementioned equation), suggests that throughout the crisis period an estimated extra 242 deaths occurred per month (appendix p 4). There was a mean of 153 additional deaths per month from circulatory system diseases, 17 from nervous system diseases, 13 from digestive diseases, five from adverse events during medical treatment, four from infectious diseases, two from suicides, two from mental

	≤19 years	20–34 years	35–44 years	45–64 years	65–74 years	≥75 years
Overall	0·00074 (–0·0011 to 0·0025)	–0·0074 (–0·0089 to –0·0059)*	–0·0021 (–0·0045 to 0·00028)	0·00073 (–0·0054 to 0·0069)	0·014 (0·0072 to 0·020)†	0·056 (0·042 to 0·071)*
Sex						
Males	0·0013 (–0·00096 to 0·0035)	–0·013 (–0·016 to –0·0093)*	–0·0059 (–0·0096 to –0·0023)†	0·000046 (–0·0085 to 0·0086)	0·010 (–0·0017 to 0·022)	0·047 (0·027 to 0·066)*
Females	0·00016 (–0·0018 to 0·0021)	–0·0019 (–0·0035 to –0·00031)‡	0·0018 (–0·0013 to 0·0047)	0·0030 (–0·0028 to 0·0089)	0·015 (0·0052 to 0·025)†	0·069 (0·049 to 0·089)*
Suicides						
Males	0·00031 (–0·000039 to 0·00067)	0·00031 (–0·00066 to 0·0013)	0·00048 (–0·00030 to 0·0013)	0·0011 (–0·00000068 to 0·0022)	0·00083 (0·00026 to 0·0014)†	–0·00019 (–0·00072 to 0·00033)
Females	0·000014 (–0·00012 to 0·00014)	0·00028 (–0·00018 to 0·00074)	0·00029 (0·000083 to 0·00050)‡	0·00039 (–0·00014 to 0·00092)	0·00032 (–0·00010 to 0·00074)	0·00015 (–0·000048 to 0·00034)
Homicides						
Males	0·00010 (–0·00024 to 0·00044)	–0·00031 (–0·00098 to 0·00036)	–0·00021 (–0·00067 to 0·00024)	0·00027 (–0·00054 to 0·0011)	0·00013 (–0·00029 to 0·00054)	0·000077 (–0·00010 to 0·00026)
Females	0·000095 (–0·00011 to 0·00029)	–0·00011 (–0·00036 to 0·00014)	–0·00019 (–0·00053 to 0·00016)	0·000053 (–0·00019 to 0·00031)	0·00019 (–0·000084 to 0·00046)	0·00014 (–0·000087 to 0·00037)
Vehicular accidents						
Males	–0·0010 (–0·0028 to 0·00071)	–0·0065 (–0·0085 to –0·0044)*	–0·0025 (–0·0040 to –0·0096)†	–0·0014 (–0·0031 to 0·000305)	0·00062 (–0·00023 to 0·0014)	–0·00058 (–0·0013 to 0·00014)
Females	–0·000056 (–0·00062 to 0·00050)	–0·00051 (–0·0017 to 0·00066)	0·00053 (0·00010 to 0·00095)‡	–0·00053 (–0·0015 to 0·00046)	–0·00017 (–0·00077 to 0·00042)	–0·00017 (–0·00082 to 0·00047)
Circulatory system diseases						
Males	0·00012 (–0·000078 to 0·00031)	–0·0021 (–0·0032 to –0·00097)†	–0·0019 (–00037 to –0·000054)‡	0·0014 (–0·0038 to 0·0066)	0·0065 (–0·0028 to 0·016)	0·027 (0·016 to 0·039)*
Females	0·00014 (0·000040 to 0·00023)†	–0·00030 (–0·0011 to 0·00045)	–0·000056 (–0·0014 to 0·0013)	0·0010 (–0·0012 to 0·0033)	0·012 (0·0062 to 0·018)†	0·043 (0·023 to 0·062)*
Cancer						
Males	–0·000036 (–0·00069 to 0·00061)	0·00024 (–0·00092 to 0·0014)	0·00011 (–0·0016 to 0·0018)	0·0019 (–0·0052 to 0·0089)	0·0021 (–0·0072 to 0·011)	–0·0062 (–0·017 to 0·0049)
Females	–0·00016 (–0·00066 to 0·00035)	–0·00046 (–0·0011 to 0·00021)	0·0017 (0·000047 to 0·0034)‡	0·0031 (–0·00049 to 0·0067)	0·0017 (–0·0036 to 0·0071)	–0·0065 (–0·014 to 0·00069)
Nervous system diseases						
Males	0·000074 (–0·00029 to 0·00044)	0·00055 (–0·000062 to 0·0012)	0·00065 (0·00013 to 0·0012)‡	0·00078 (–0·00083 to 0·0024)	0·000054 (–0·00085 to 0·00096)	0·0015 (0·000078 to 0·0029)‡
Females	0·00011 (–0·00033 to 0·00055)	–0·00022 (–0·00055 to 0·00012)	0·00024 (–0·00023 to 0·00071)	0·00079 (–0·000081 to 0·0017)	0·0014 (0·00017 to 0·0026)‡	0·0014 (–0·00038 to 0·0032)
Respiratory disorders						
Males	–0·00021 (–0·00093 to 0·00051)	–0·00030 (–0·00097 to 0·00037)	–0·00039 (–0·00087 to 0·00010)	–0·0049 (–0·0066 to –0·0032)*	–0·0081 (–0·013 to –0·0035)†	–0·0083 (–0·013 to –0·0039)†
Females	–0·00040 (–0·00084 to 0·000038)	–0·000050 (–0·00048 to 0·00038)	0·000012 (–0·00039 to 0·00042)	–0·0025 (–0·0039 to –0·0010)†	–0·0025 (–0·0043 to –0·00059)‡	–0·014 (–0·017 to –0·010)*

(Table 3 continues on next page)

	≤19 years	20–34 years	35–44 years	45–64 years	65–74 years	≥75 years
(Continued from previous page)						
Digestive diseases						
Males	−0·000017 (−0·00023 to 0·00019)	−0·00028 (−0·00084 to 0·00029)	−0·00050 (−0·0014 to 0·00041)	0·00056 (−0·0013 to 0·0024)	0·00061 (−0·00098 to 0·0022)	0·0031 (0·0012 to 0·0049)†
Females	−0·00015 (−0·00034 to 0·000050)	0·000012 (−0·00032 to 0·00035)	−0·00021 (−0·00058 to 0·00016)	0·00037 (−0·00073 to 0·0015)	0·0012 (0·000075 to 0·0023)‡	0·0048 (0·0032 to 0·0064)*
Disorders relating to pregnancy and childbirth	−0·000057 (−0·00017 to 0·000054)	−0·000062 (−0·00018 to 0·000053)	−0·000055 (−0·00017 to 0·000056)	..	..	..
Mental health problems						
Males	0·00000041 (−0·00000054 to 0·000014)	−0·000080 (−0·00018 to 0·000023)	−0·00014 (−0·00036 to 0·000082)	−0·000057 (−0·00052 to 0·00040)	−0·000029 (−0·00019 to 0·00014)	0·00038 (0·00014 to 0·00062)†
Females	−0·00000023 (−0·00000065 to 0·00000018)	0·000053 (−0·000081 to 0·00019)	−0·000083 (−0·00024 to 0·000075)	−0·000076 (−0·00019 to 0·000045)	0·00042 (−0·000067 to 0·00091)	0·0011 (0·00033 to 0·0019)†
Infectious diseases						
Males	0·00020 (−0·000028 to 0·00042)	−0·0000000080 (−0·00024 to 0·00024)	−0·00021 (−0·00051 to 0·000097)	−0·00065 (−0·0016 to 0·00029)	−0·00077 (−0·0019 to 0·00035)	−0·0020 (−0·0042 to 0·00012)
Females	−0·000041 (−0·00023 to 0·00014)	−0·00083 (−0·00024 to 0·000074)	0·000021 (−0·00018 to 0·00022)	−0·00035 (−0·00086 to 0·00016)	−0·0013 (−0·0024 to −0·000094)‡	−0·0031 (−0·0055 to −0·00071)‡
Adverse events during medical treatment						
Males	−0·000027 (−0·00011 to 0·000059)	0·000035 (−0·00013 to 0·00020)	0·00052 (−0·00071 to 0·00018)	0·00037 (−0·00013 to 0·00087)	0·00099 (0·00034 to 0·0016)†	0·00065 (0·00031 to 0·00098)†
Females	−0·000028 (−0·000094 to 0·000039)	0·000099 (−0·000076 to 0·00027)	−0·000055 (−0·00022 to 0·00011)	0·00062 (0·00041 to 0·00084)*	0·00077 (0·00042 to 0·0011)*	0·00048 (0·00033 to 0·00063)*

Data are mortality trend difference (95% CI) for before versus after the onset of the crisis by ordinary least-squares regressions weighted by the square root of the regional population. 95% CIs are based on SEs that have been corrected for clustering by region. Age-standardised death rates per 100 000 inhabitants were used as dependent variables. *p<0·001. †p<0·01. ‡p<0·05.

Table 3: **Changes in mortality rate trends by age, sex, and cause of death**

health problems, one from homicide, and one from disorders relating to pregnancy and childbirth, whereas 25 fewer deaths per month occurred from vehicular accidents, 44 from cancer, and 33 from respiratory causes (appendix p 2). The reported mean number of excess deaths from infectious diseases, despite the negative trend shown earlier, was a result of higher extrapolated estimates during the first year of the crisis. A mean of 104 excess deaths were in males compared with 142 in females. The numbers presented in the appendix (p 2) depend on extrapolations patterns before the crisis and thus should be interpreted with caution, but they give a rough impression about the potential magnitude of the effects.

Discussion

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 was more than two times stronger than it was for males, suggesting that women have carried a bigger burden of the crisis. The evidence on sex and mortality during crises is not conclusive,[15,22,23] but our findings are consistent with evidence showing that self-assessed health deteriorated more for women than for men during the financial crisis in Greece.[24] We also found that older age groups experienced more negative changes in overall mortality than the younger population, who even experienced some improvements in mortality trends after the onset of the crisis, largely as a result of reduced mortality from traffic accidents. The worsening trends among elderly people occurred mainly in circulatory and digestive system diseases. There are many potential explanations for this pattern, including an effect from substantial reductions in pensions for those above age 65 years, or a decline in health-care facilities and resources, both preventive and therapeutic, affecting primarily the most vulnerable (ie, elderly people). Findings from a recent study in England[25] showed mortality rates among pensioners aged 85 years and older increased after the onset of compared with before the financial crisis, and this was associated with reductions in spending on income support.

In line with previous evidence,[12–14] our results show that deaths from suicide have increased after the onset of compared with before the crisis, particularly among men. Our results also show that deaths due to vehicular accidents declined faster after the onset of than before the crisis, adding to previous speculation that individuals reduced their car travel and switched to cheaper forms of transportation because of a steep increase in fuel price.[26] This favourable pattern occurred predominantly among young men. Deaths from circulatory diseases, the most common cause of mortality in the study period, also

continued to decline after the onset of compared with before the crisis, as previous evidence has shown,[27] but, as for overall mortality, more slowly. Cancer rates continued to decline; however, the changes between after the onset of versus before the crisis were not statistically significant. The effect of the crisis on lifestyle-related disorders, such as cancer and cardiovascular disease, is hard to capture, because years can pass before behavioural changes—some healthy and some not—affect outcomes. A recent report[28] provided empirical evidence that smoking and alcohol consumption declined between 2009 and 2014 in Greece. The latest Organisation for Economic Co-operation and Development (OECD) data suggest that in 2014, Greece had the highest number of daily smokers across all OECD countries, with 27% of the population aged 15 years or older smoking on a daily basis.[29] After the beginning of the economic crisis, the number of cigarettes smoked per person started to decline in Greece.[30] Some evidence also suggested that a 2011 tax increase on cigarettes led to a decrease in cigarette consumption within 1 year of its implementation.[31] Changes in smoking habits might also explain our finding of a lower mortality rate due to respiratory diseases, although these changes may take a long time to be reflected fully in mortality rates. The economic crisis has also been linked to a resurgence of malaria in some parts of Greece and an increase in new HIV infections.[32] However, these changes were not possible to capture in our analysis of mortality rates.

A finding that needs particular attention is the sharp increase in deaths by adverse events during medical treatment since the beginning of the crisis. This finding provides some novel evidence on the association between quality of health care and health outcomes, because this cause of death has not been well explored previously. Investigators of previous studies from the USA[33,34] argued that cyclical fluctuations in the quality of health care might explain cyclical movements in mortality, because during financially difficult periods better health-care workers are attracted to publicly funded health-care services. Our results are in contrast with findings from these studies, primarily because our findings do not support their argument that mortality rates are cyclical. The increase in deaths by adverse events during treatment we reported could be explained by serious shortages of medical staff and burnout among health workers in Greece.[35] Elderly people seemed to be most affected by this increase in deaths by adverse events. An alternative explanation might be a greater willingness to acknowledge adverse events during treatment as a cause of death, but no such change has happened to our knowledge. Additional studies on the effects of financial crises on mortality should be done to verify this finding.

We cannot answer how many excess deaths the crisis has caused definitively because, owing to the nature of our data, causality cannot be assumed. Moreover, there is no guarantee that the trajectory of deaths would have continued unchanged if the crisis had not happened. With these caveats in mind, we estimated the difference in slopes of age-adjusted and sex-adjusted mortality rates, and translated these into absolute numbers of excess deaths per month during the crisis period. Our findings suggest that, although some causes of death such as suicides and homicides have captured more attention both in the academic literature[36] 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 than for men.

Our study has 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. Additionally, data on suicides are sensitive; because of religious attitudes and the stigma surrounding suicide, some suicides might be misclassified on death certificates. However, we found no evidence that this phenomenon changed during the crisis period. Also, although we weighted our estimations with the regional population, we could not explicitly control for migration fluctuations because of absence of data. However, by controlling for region-specific fixed effects and for region–time interactions, we can, to some extent, mitigate this problem. Also, we were not able to establish the mechanisms that led to the results reported in our paper. We offer some explanations of why some trends occurred, based on what previous evidence has shown, but we cannot identify definitive reasons behind these, and thus claims of causation should be avoided.[37] Further research is needed to investigate associations between mortality and macroeconomic indicators, such as unemployment, controlling for the effect of health insurance and social protection schemes, to better understand the drivers of the health effects of the crisis. Further analysis of lag effects and the use of appropriate control groups is also needed in future research.

Contributors

IL and CS conceived the study. IL did the data analysis. All authors designed the study, interpreted and discussed the results, and wrote, revised, and approved the manuscript.

Declaration of interests

We declare no competing interests.

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