

# BMJ Open The impact of economic austerity and prosperity events on suicide in Greece: a 30-year interrupted time-series analysis

Charles C Branas,<sup>1</sup> Anastasia E Kastanaki,<sup>2</sup> Manolis Michalodimitrakis,<sup>2</sup> John Tzougas,<sup>3</sup> Elena F Kranioti,<sup>4</sup> Pavlos N Theodorakis,<sup>5</sup> Brendan G Carr,<sup>1</sup> Douglas J Wiebe<sup>1</sup>

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<sup>1</sup>University of Pennsylvania, Philadelphia, USA

<sup>2</sup>Faculty of Medicine, University of Crete, Iraklion, Greece

<sup>3</sup>Hellenic Statistical Authority, Piraeus, Greece

<sup>4</sup>Edinburgh Unit for Forensic Anthropology, SHCA, University of Edinburgh, UK

<sup>5</sup>WHO National Counterpart for Mental Health, Athens, Greece

## Correspondence to

Professor Charles C Branas; [cbranas@upenn.edu](mailto:cbranas@upenn.edu)

## ABSTRACT

**Objectives:** To complete a 30-year interrupted time-series analysis of the impact of austerity-related and prosperity-related events on the occurrence of suicide across Greece.

**Setting:** Greece from 1 January 1983 to 31 December 2012.

**Participants:** A total of 11 505 suicides, 9079 by men and 2426 by women, occurring in Greece over the study period.

**Primary and secondary outcomes:** National data from the Hellenic Statistical Authority assembled as 360 monthly counts of: all suicides, male suicides, female suicides and all suicides plus potentially misclassified suicides.

**Results:** In 30 years, the highest months of suicide in Greece occurred in 2012. The passage of new austerity measures in June 2011 marked the beginning of significant, abrupt and sustained increases in total suicides (+35.7%,  $p<0.001$ ) and male suicides (+18.5%,  $p<0.01$ ). Sensitivity analyses that figured in undercounting of suicides also found a significant, abrupt and sustained increase in June 2011 (+20.5%,  $p<0.001$ ). Suicides by men in Greece also underwent a significant, abrupt and sustained increase in October 2008 when the Greek recession began (+13.1%,  $p<0.01$ ), and an abrupt but temporary increase in April 2012 following a public suicide committed in response to austerity conditions (+29.7%,  $p<0.05$ ). Suicides by women in Greece also underwent an abrupt and sustained increase in May 2011 following austerity-related events (+35.8%,  $p<0.05$ ). One prosperity-related event, the January 2002 launch of the Euro in Greece, marked an abrupt but temporary decrease in male suicides (−27.1%,  $p<0.05$ ).

**Conclusions:** This is the first multidecade, national analysis of suicide in Greece using monthly data. Select austerity-related events in Greece corresponded to statistically significant increases for suicides overall, as well as for suicides among men and women. The consideration of future austerity measures should give greater weight to the unintended mental health consequences that may follow and the public messaging of these policies and related events.

## Strengths and limitations of this study

- The first multidecade, national analysis of suicide in Greece using monthly data.
- The first robust statistical time-series tests of the abrupt effects of *both* prosperity-related and austerity-related events on suicide.
- The first time-series study of suicide to include a sensitivity analysis that figures in undercounting and misclassification of suicides.
- The absence of nonfatal self-directed injuries was a limitation in our analysis.
- The significant shifts that we identified may have been related to the austerity measures themselves or could have been related to different, but unmeasured, events that happened in the same months as our interruptions.

## INTRODUCTION

The ongoing economic crisis in developed nations is the worst since the Great Depression<sup>1 2</sup> and Greece is thought to have been more affected than any other European country.<sup>3</sup> Numerous academic articles and commentaries have been published in recent years speculating about the impact of recent economic austerity measures in Greece.<sup>1 3–5</sup> These austerity measures followed numerous economic inconsistencies in the national finances of the Greek state that have been viewed as a foundational economic crisis affecting the European economy and, by extension, the world economy.

The weight of this crisis situation and the Greek austerity measures have been highly publicised around the world. Not surprisingly, this publicity and the toxic economic conditions accompanying the austerity measures have also become the leading source of public consternation in Greece itself, exacting considerable stress and strain on the Greek

public.<sup>1 4</sup> Everyday citizens in Greece have faced an increasingly bleak crisis and their local media outlets discuss little else. National debt reduction strategies and new austerity measures are publicly, and often abruptly, announced and then followed by large demonstrations, labour strikes, riots and police actions.

The strain on the Greek public that has persisted for several years now has prompted academic discussion of the potential health effects of the austerity measures. In this regard, fluctuations of suicides in Greece have been a lead topic of discussion, with numerous commentators concluding that the recent austerity measures have indeed led to increased suicides in Greece. This conclusion has, however, been appropriately met with scepticism<sup>6-8</sup> and no large-scale, systematic longitudinal analysis has yet been completed to inform the ongoing debate as to whether austerity measures have led to statistically higher suicide rates in Greece.<sup>4 6 7 9 10</sup> To help fill this gap, we undertook a 30-year interrupted time-series analysis of several abrupt and highly publicised austerity-related events and the monthly occurrence of suicide across Greece. For comparison, we also considered the impact of prosperity-related events and suicide across Greece over the same time period and investigated the potential bias of suicide under-reporting on our analyses.

## METHODS

### Mortality data

We analysed suicides that occurred in Greece from 1 January 1983 to 31 December 2012. Data were assembled as monthly counts of all suicides and monthly counts of suicide separately for men and women. Man–woman differences have been demonstrated in prior studies of broad economic trends and suicide in Greece.<sup>11</sup> Suicide counts were obtained from death certificates of Greek residents who died in Greece over the study period.

National suicide data were provided by the Hellenic Statistical Authority (ELSTAT), an independent, national authority in Greece that follows European and international standards of statistical practice and data collection.<sup>12 13</sup> These data represented suicides from all mechanisms (ICD9 E-codes E950-E958) and have been used in past yearly suicide analyses in Greece; our annual suicide counts matched those reported in these past suicide analyses.<sup>4 7 14</sup>

In Greece, violent deaths, accidents and suspected suicides prompt investigative and data collection protocols involving the police, local coroners and public prosecutors. These legal authorities are obliged to perform inquiries and order autopsies by forensic medical doctors at state hospitals.<sup>15</sup> Death certificates in Greece must be completed before burial, despite forensic investigations that may still be ongoing. As a result, first-line medical causes of death (or so-called R-codes, ICD-10, R00-R99) are occasionally used as placeholder diagnoses

on death certificates<sup>16 17</sup> until the final cause of death (ie, accident, suicide or homicide) can be amended following further investigation.<sup>18</sup>

Despite these standard procedures, analyses of death certificate data are subject to bias that can result from inaccurately recorded causes of death. Prior studies have pointed to the misclassification of suicide as a source of bias for national analyses in numerous countries, including Greece.<sup>19-21</sup> Intentional (to avoid stigma) and unintentional (inability to determine victim intent) reasons may drive under-reporting of suicide in Greece.<sup>14</sup> In particular, the Greek Orthodox Church considers suicide a major sin and condemns suicide victims to be interred without a burial service.<sup>14 22</sup> This has caused some to contend that suicide rates in Greece are among the lowest in Europe partly because of under-reporting and misclassification for religious reasons.<sup>14 23</sup>

Given this potential for misclassification, we performed a sensitivity analysis based on prior work, including a comparison of official suicide mortality statistics from ELSTAT and validated coroner death certificate data for the same suicides at the regional level (the Island of Crete).<sup>24</sup> Discrepancies between the two sources indicated that suicidal poisonings, falls, drownings and hangings most likely represented the vast majority of potentially misclassified suicides. In all instances of misclassification, suicides were undercounted; suicides were not overcounted in any mechanism of suicide category. The remaining mechanisms of suicide were either very infrequently undercounted (ie, firearm suicides) or very small in number (ie, cutting/piercing suicides) and excluded from further sensitivity analyses.

Having determined potentially misclassified mechanisms of suicide in our data, we then obtained monthly counts of deaths due to accidental poisonings, falls, drownings and suffocations (ICD9 E-codes E850-869, 880-888, 910-915) from ELSTAT. On the basis of the prior comparison of official suicide statistics and validated coroner data at the regional level, we created a new time series where the event counts in each month were calculated as total recorded suicides across Greece plus 17.6% of all potentially misclassified accidental deaths by poisonings, falls, drownings and suffocations across Greece. This 17.6% inflation of national suicides maintained the monthly variability in potentially misclassified accidental deaths, while increasing the average suicides per month to correspond with the overall misclassification rate found at the regional level.

Thus, our final working data were comprised of four separate time series: (1) all suicides, (2) male suicides, (3) female suicides and (4) all suicides plus potentially misclassified suicides. Each of these time series had 360 monthly observations in time over a 30-year study period.

### Austerity and prosperity interruptions-in-time

We searched news media archives and other publications to identify austerity-related and prosperity-related events

that occurred in Greece during the study period and that were highly publicised and thus most likely detected by the Greek public. In being highly publicised and widely known to the general public, these events were hypothesised as potentially having had an impact on the mental health and well-being of individual Greeks, thereby potentially leading to increases or decreases in suicide.<sup>1 3 25–30</sup> A total of 12 such events were identified from January 1983 to December 2012. Each event was represented in the working data set as a separate time-series variable coded 0 for each month before the event occurred and coded 1 for the month in which the event occurred and each month thereafter (ie, a step variable). This allowed us to treat each event as an interruption-in-time for our analyses.

### Statistical analyses

We first completed visual inspections and descriptive analyses of the four time series and the interruptions-in-time. Descriptive analyses included the calculations of sums, means, SDs and linear trends.

We then conducted an interrupted time-series analysis using autoregressive integrated moving average (ARIMA) models and transfer functions to test the hypothesised impact of each austerity and prosperity interruption on suicide in Greece.<sup>31 32</sup> Separately for each of our four time series, this modelling involved identifying the ARIMA model that best fit the time series and then testing each interruption variable with three commonly used transfer functions. To do this, we applied a zero-order transfer function to a step variable, a first-order transfer function to a step variable, and a first-order transfer function to a differenced step variable (ie, a pulse variable coded 1 for the month in which the event occurred and coded 0 for all other months). This approach allowed us to investigate the form of a given hypothesised interruption and whether it was associated with: (1) an abrupt and sustained, (2) a gradual and sustained or (3) an abrupt but temporary, increase or decrease in the monthly counts of suicide (see online supplementary appendix). As the modelling procedure was carried out, we retained any intervention variable in our models if the *p* value on its parameter was  $p < 0.05$ . After the modelling was completed, however, we used  $p < 0.01$  as the critical value for assessing the statistical significance of the effect estimates for the parameters that had been retained in the final models. This was done to account for multiple testing biases given the large number of events that were investigated as interruptions in four separate suicide time series. The mean number of additional suicides that occurred per month after a specific interruption-in-time compared to the mean number of suicides that occurred per month before the interruption-in-time was used to calculate a per cent change in suicide linked to a specific prosperity or austerity interruption-in-time event.

As part of the ARIMA modelling procedure, each time series was tested for stationarity in mean and variance.

Any systematic trend in a time series was accounted for by differencing the time series, that is, subtracting from each observation the value of a preceding observation at a lag that was indicated by conventional diagnostics. This serves to detrend a time series and makes it possible to test whether it was different in level after versus before the onset of each hypothesised interruption. For each of the four time series that were analysed, plots of the autocorrelation function and partial autocorrelation function and the *Q* statistic were used to test whether the ARIMA model that was fit to each time series, before and after the transfer function modelling, produced white noise residuals.<sup>32 33</sup> SCA WorkBench V.6.2.1 was used for the analysis (Scientific Computing Associates Corp., Villa Park, Illinois, USA).

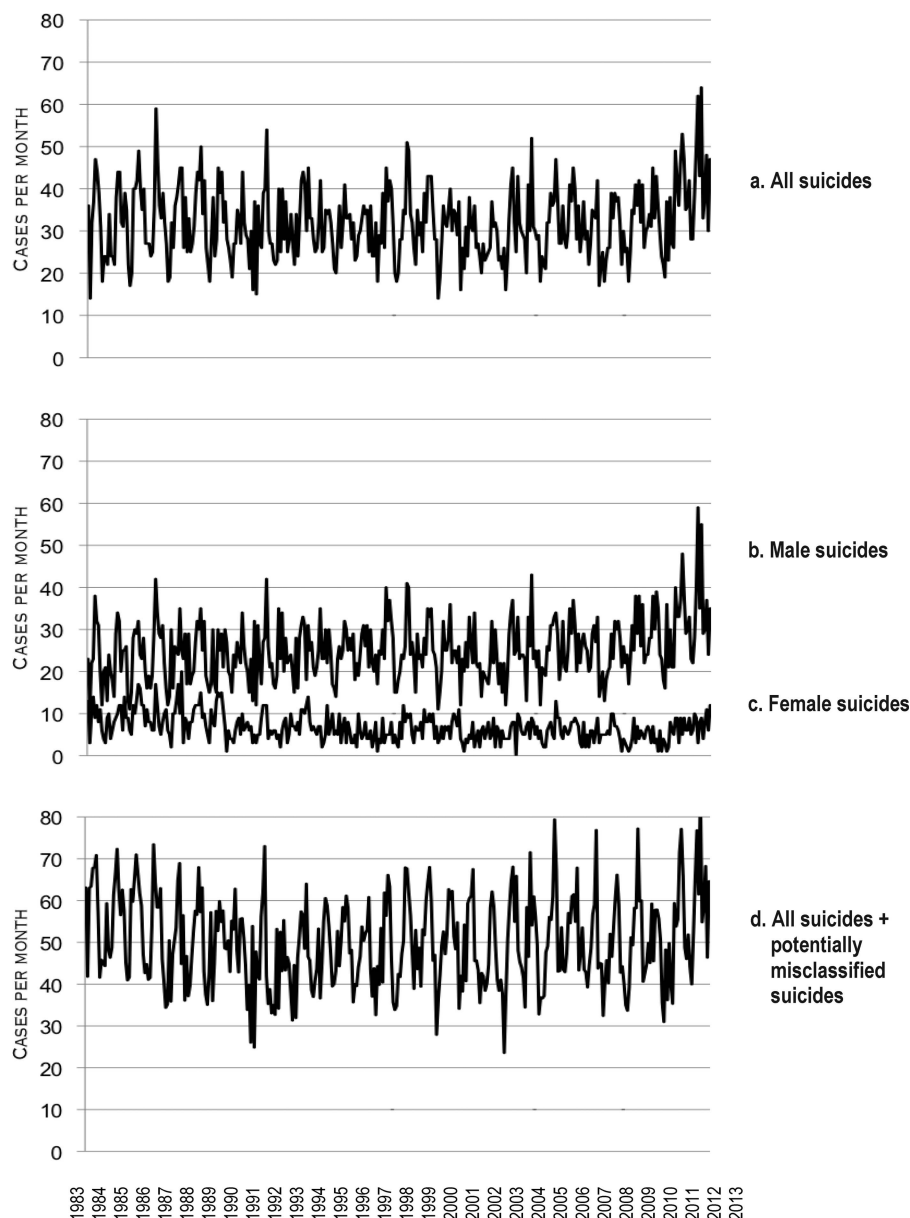
We used ARIMA modelling for this study because, before testing for the impact of hypothesised interruptions-in-time, the ARIMA modelling technique enabled us to fit a statistical model to the time series that accurately predicted the monthly number of suicides that occurred in Greece over the time series. It did this by predicting each monthly observation of suicides as a function of the number of suicides that occurred in one or more past months, instead of using regression covariates to try to fit a model to the suicide time series. Since ARIMA models must be identified from the time series data themselves, rather than separate regression covariates, relatively long time series, typically more than 50 observations in time, are required and most appropriate.<sup>31 32</sup> Recent, related works of longer term processes-through-time have involved yearly observations, been less than 50 total observations in time, and have been analysed using standard regression models.<sup>11</sup> Since our data set was a monthly time series consisting of  $n=360$  monthly observations and our aim was to test the impact of events that were abrupt interruptions-in-time, we appropriately chose ARIMA models for our analyses.

### RESULTS

Over our study period, from 1 January 1983 to 31 December 2012, Greece went from a population of 9.9 million to 11.1 million. Its population's life expectancy at birth went from 75 to 81 years over this 30-year period. Its gross domestic product (GDP) per capita grew from US\$4787 in 1983 to US\$25 309 in 2012 and its unemployment rate grew from 7.6% in 1983 to 24.3% in 2012.<sup>34–38</sup>

Over the same 30-year period, 11 505 suicides, 9079 by men and 2426 by women, occurred in Greece. The maximum number of monthly reported suicides that occurred over the 30-year study period was 64 in July 2012, followed by 62 in May 2012. The minimum number of monthly reported suicides was 14 in both February 1983 and November 1999. Over the entire study period, linear trend analyses showed small average monthly changes of +0.005 total suicides per month, +0.01 male suicides per month and −0.01 female

**Figure 1** Monthly trends in suicide across Greece for all suicides, gender subcategories of suicide, and potentially misclassified suicides.



suicides per month. Over the entire 30-year study period, the average monthly number of suicides was 32.0 ( $\pm 8.5$ ) overall, 25.2 ( $\pm 7.2$ ) for males and 6.7 ( $\pm 3.3$ ) for females (figure 1).

#### Interruptions-in-time that were tested

We identified 12 interruptions that may have impacted suicide over the study period, four initial prosperity-related events and eight subsequent austerity-related events. Prosperity-related events began in 1997 when the International Olympic Committee announced that Greece would host the 2004 Olympic Games, during the 2000–2002 period when Greece was accepted into the Economic and Monetary Union of the European Union and launched the Euro, until 2004 when the Olympic Games occurred. The austerity-related events occurred from 2008 to 2012 with the start of the Greek recession,<sup>39 40</sup> through various

financial bailout packages, riots, strikes and protests, until a Greek pensioner committed a highly publicised suicide in the main square of Athens in response to austerity conditions (table 1).

#### Analyses of interruptions-in-time, overall and by gender

The total number of suicides in Greece underwent a significant, abrupt and sustained increase of 11.2 average suicides per month (35.7%) in June 2011, when the Greek government passed a second series of austerity measures ( $p=0.0004$ ). No other austerity-related or prosperity-related events corresponded to significant shifts in total suicides (table 2, figure 2A).

The launch of the Euro currency in Greece in January 2002 marked an abrupt but temporary decrease in male suicides ( $-27.1\%$ ,  $p<0.05$ ), which then gradually returned to the pre-event average. Following this, the number of suicides by men in Greece underwent significant, abrupt and



**Table 1** Prosperity-related and austerity-related economic events in Greece that were tested as time-series interruptions from 1983–2012

Month	Event type	Description of economic interruption
September 1997	Prosperity-related	International Olympic Committee announces that Greece will host the 2004 Summer Olympic Games
June 2000	Prosperity-related	Greece is accepted into the Economic and Monetary Union of the European Union (EU)
January 2002	Prosperity-related	Greece is among the first wave of European countries to launch Euro banknotes and coins
August 2004	Prosperity-related	Olympic Games are held in Athens, Greece
October 2008	Austerity-related	Start of the recession in Greece as marked by the beginning of a sustained per cent reduction in national gross domestic product and protesters confronting police, who responded with tear gas
March 2010	Austerity-related	Greek government announces a series of new austerity measures amid strikes, riots and protests
May 2010	Austerity-related	Greek government passes a series of new austerity measures alongside widespread stoppages, protests, riots and violence
May 2011	Austerity-related	Large organised public protests of austerity measures in multiple major cities across Greece
June 2011	Austerity-related	Greek government passes a series of new austerity measures alongside widespread protests, strikes, riots and violence
October 2011	Austerity-related	Greek government passes a series of new austerity measures alongside widespread protests and strikes
February 2012	Austerity-related	Greek government passes a series of new austerity measures amid large protests, riots and violence
April 2012	Austerity-related	Greek pensioner openly commits highly publicised suicide in the main square of Athens in response to austerity conditions

sustained increases of 3.2 average suicides per month (13.1%,  $p=0.0009$ ) in October 2008, when the Greek recession began, and an additional 5.2 average suicides per month increase (18.5%,  $p=0.0002$ ) in June 2011. The number of suicides by men in Greece then underwent an abrupt but temporary increase of 9.8 suicides per month (29.7%,  $p=0.03$ ) in April 2012, gradually returning to the pre-event average (table 2, figure 2B).

Among women in Greece, the incidence of suicide experienced an abrupt and sustained increase of 2.4 average suicides per month (35.8%,  $p=0.04$ ) in May 2011. No other austerity-related or prosperity-related events corresponded to significant shifts in this time series. (table 2, figure 2C).

### Sensitivity analyses

A combined total of 18 092 suicides plus potentially misclassified suicides occurred in Greece over the 30-year study period, corresponding to an average of 50.3 ( $\pm 10.8$ ) fatalities per month. Sensitivity analyses of this time series revealed that the number of recorded fatalities increased significantly, abruptly and in a sustained way in June 2011 by an average of 10.2 deaths per month (20.5%,  $p=0.0004$ ). No other austerity-related or prosperity-related events corresponded to significant shifts in this time series (table 2, figure 2D).

### DISCUSSION

Select austerity-related economic events in Greece corresponded to statistically significant changes in suicide.

The June 2011 economic interruption was especially remarkable in that it led to significant, abrupt and sustained increases in total suicides, by 36%, and male suicides, by 19%. Sensitivity analyses that figured in under-counting of suicides also found a significant, abrupt and sustained increase in June 2011, further reinforcing the importance of this month. An abrupt and sustained increase of borderline significance was also found for women in Greece in May 2011.

Relative to other months in which a new series of austerity measures were passed by the Greek government, June 2011 may have been most significant because it was the first part of a larger austerity plan that passed by a very narrow vote. This passage occurred despite polls suggesting that the vast majority of the Greek public were opposed to the austerity plan. It also occurred amid multi-day demonstrations, which turned violent as protestors rioted outside the Greek Parliament, and strikes that halted most public services and closed Greek banks.

Men in Greece also experienced a significant, abrupt and sustained 13% increase in suicide beginning in October 2008, the same month as the documented start of the recession in Greece. This well publicised start was marked by the first sustained reduction in the Greek GDP and has pervaded the national public conscience ever since. As a very important contrast, men in Greece also experienced an abrupt but temporary 27% decrease in suicide with the launch of the Euro currency in Greece in January 2002. Although potentially in contrast to prior theory,<sup>41 42</sup> this suggests that positive, well-

**Table 2** Time-series autoregressive integrated moving average (ARIMA) modelling results of the impact of austerity-related and prosperity-related events on four monthly suicide time series studied in Greece from 1983 to 2012

	All suicides					Male suicides					Female suicides					All suicides + potentially misclassified suicides				
	Abrupt permanent test		Gradual permanent test		Abrupt temporary test	Abrupt permanent test		Gradual permanent test		Abrupt temporary test	Abrupt permanent test		Gradual permanent test		Abrupt temporary test	Abrupt permanent test		Gradual permanent test		Abrupt temporary test
			Growth rate		Decay rate			Growth rate		Decay rate			Growth rate		Decay rate			Growth rate		Decay rate
	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size	Size
September 1997	-0.42	0.26	0.42	2.21	0.77	-0.16	-0.13	0.44	0.17	0.99	0.15	0.13	0.13	0.07	0.95	0.58	0.51	0.37	0.08	0.62
June 2000	-1.25	0.01	1.07	2.68	0.78	0.05	0.05	0.64	0.18	0.77	0.87	-1.79	0.94	0.71	0.45	0.92	1.38	0.53	0.14	0.88
January 2002	-0.44	-0.51	-0.18	-0.38	0.83	-0.37	-0.77	-0.46	-6.62*	0.84***	-0.28	-0.21	0.53	2.09	0.06	-1.12	-3.41	0.91	1.24	0.45
August 2004	1.01	0.51	0.52	-2.67	0.42	0.71	0.27	0.67	1.33	0.82	0.30	0.23	0.59	0.24	0.74	0.13	-0.16	0.64	0.33	1.01
October 2008	1.95	3.57	0.78	4.43	0.36	3.24***	5.30	0.65	2.01	0.03	1.23	-1.63	0.32	0.43	0.68	0.14	0.07	0.82	0.04	1.12
March 2010	12.31	0.23	1.07	0.28	0.62	-0.80	-0.69	0.44	10.70	0.07	-1.30	-0.79	0.48	0.11	0.50	-3.42	-3.02	0.32	7.78	0.69
May 2010	0.04	0.10	0.59	1.50	0.75	-2.08	-1.51	0.35	0.15	0.69	-0.82	-0.23	0.78	0.61	0.53	-4.62	-1.87	0.61	0.63	7.28
May 2011	0.48	0.44	0.60	0.39	0.95	-6.02	-6.26	0.24	0.01	0.83	2.37*	4.31*†	0.80*†	3.43	0.66	-3.81	-4.27	0.40	0.07	0.94
June 2011	11.20***	5.87	0.50	-7.68	0.20	5.16***	10.42*†	0.79*†	11.86*†	0.89*†	-3.19	-5.99	0.67	-5.68	0.22	10.20***	6.54	0.37	-6.30	0.14
September 2011	1.24	1.30	0.21	7.33	0.59	-5.35	-3.06	0.75	8.83	0.12	1.31	1.83	0.55	0.40	0.89	1.46	1.65	0.45	8.98	0.47
February 2012	1.69	1.39	0.52	-9.68	0.46	8.65	-3.06	0.75	-9.03	0.12	0.98	0.56	0.49	0.14	1.42	2.33	0.12	1.27	-10.34	0.61
April 2012	4.64	2.39	0.42	0.16	1.70*	-9.03	-9.18	0.04	9.81*	0.78***	0.44	0.37	0.43	0.10	-1.71	6.55	6.67	0.01	-0.22	0.65

All suicide models: ARIMA(0,0,0)(0,1,1)12. Q(24 lags)=13.6. Male suicide model: ARIMA(0,0,0)(0,1,1)12. Q(24 lags)=21.6.

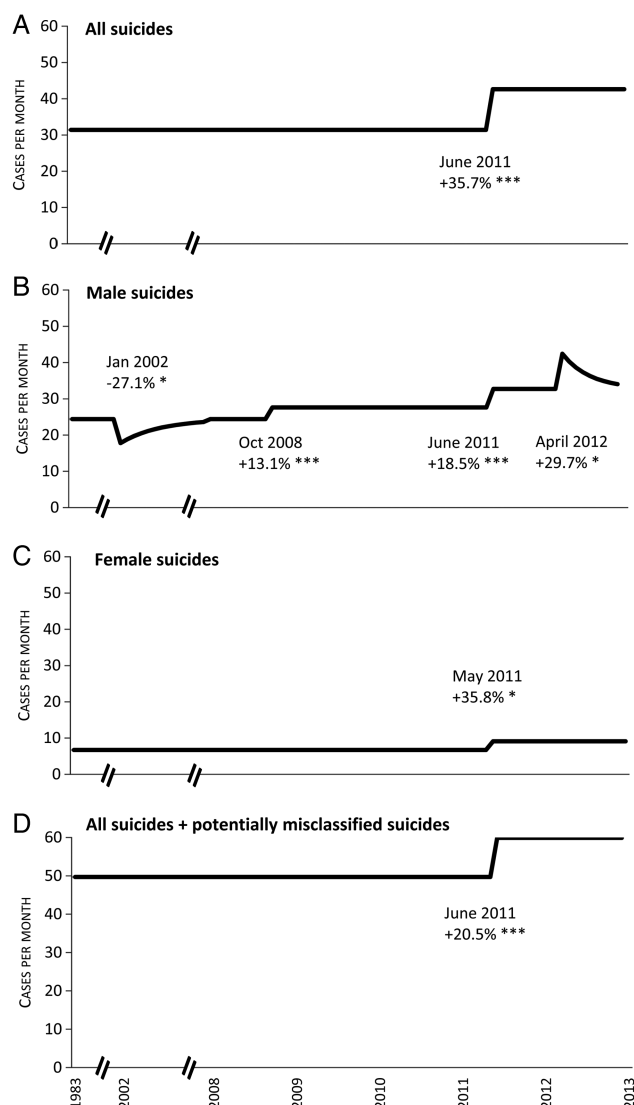
Female suicide model: ARIMA(1,0,1)(0,1,1)12. Q(24 lags)=19.8. All suicides + potentially misclassified suicides model: ARIMA(1,0,1)(0,1,1)12. Q(24 lags)=16.2.

Size: numerator coefficient. Growth rate and decay rate: denominator coefficient. Abrupt permanent test: zero order transfer function applied to step.

Gradual permanent test: first order transfer function applied to step. Abrupt temporary test: first order transfer function applied to pulse.

\*p<0.05; \*\*p<0.01; \*\*\*p<0.001.

†The coefficient was statistically significant but produced a poorly fitting estimate of the time series and thus was rejected.



**Figure 2** Estimated forms (abrupt sustained, abrupt temporary) and magnitudes (%) of statistically significant monthly interruptions in four Greek suicide time series. \* $p < 0.05$ , \*\* $p < 0.01$ , \*\*\* $p < 0.001$ .

publicised economic events can perhaps have a favourable effect on mental health outcomes like suicide.

Increases in male suicide have been documented in other countries following economic crises. Just as in these other countries, economic instability in Greece primarily affected men who were the predominant family income generators compared with women.<sup>14 19 43 44</sup> The sustained and statistically significant nature of the October 2008 and June 2011 increases for male suicides in Greece reveals the systemic and lasting effect that large government austerity programmes can have on national economic stability and public health.

Although of borderline statistical significance, men in Greece additionally demonstrated a large, but temporary, 30% increase in suicides in April 2012. This increase in male suicide followed the highly publicised suicide of a Greek male pensioner in the main square of Athens in response to austerity conditions. Although short-lived

and having a less statistically significant impact on male suicide than the prior two government-generated events, this event immediately preceded the two highest months of suicide in our entire 30-year study period.

The April 2012 austerity-related event was a personal tragedy, committed by an individual acting alone, not the Greek government. More importantly, this same individual's suicide was repeatedly covered across many news outlets as a stand-alone story that included the victim's name, method of suicide, precipitating life events, and quotes from a suicide note, all aspects of media reporting on suicide that have been statistically associated with or hypothesised to create copycat suicide behaviour.<sup>45</sup> Greek commentators have indeed argued that increased recognition of a possible austerity-suicide relationship created by media reports may have become a self-fulfilling prophecy<sup>4</sup> at some point after the economic crisis began. Thus, the news coverage and short-lived impact of this April 2012 austerity-related event point to a media-oriented trigger for the high numbers of male suicides that occurred in the 3 months that followed.

Finally, women in Greece, who accounted for approximately one of every four suicides, also experienced an abrupt and sustained increase in suicides in May 2011. Although of borderline significance, this sustained increase in female suicides among women in Greece was larger, on a percentage basis, than that in male suicides in 2011. This finding runs counter to previous research showing that economic downturns tend to result in larger increases in man, but not woman, suicides.<sup>14 19</sup>

### Prior reports and factors related to suicide in Greece

Although numerous publications and commentaries have speculated in recent years about the impact of economic austerity measures on suicides in Greece, appropriate scepticism has remained as to whether this relationship is real.<sup>6</sup> These speculations, generally based on government reports, unofficial data or the media, have placed an increase of suicides in Greece anywhere from 17% to 40%.<sup>1 3–5</sup> One study completed a valuable regression analysis of suicide trends in 54 countries, including Greece, although it was limited in that it aggregated suicides by calendar year given the WHO mortality data that were available.<sup>19</sup> This same study suggested that further analyses be conducted as monthly aggregations of suicide, which we have done here for Greece. Another, more recent study concluded that fiscal austerity, as measured by yearly trends in public expenditure reductions, as well as general trends in unemployment rates and negative economic growth, led to significant increases in overall suicide rates in Greece.<sup>11</sup> Monthly interrupted time-series analyses have also been recently completed in other Southern European countries, such as Spain, where an 8% increase in suicide was shown to follow the start of the financial crisis there in 2008.<sup>43</sup>

This is the first multidecade, national analysis of suicide in Greece using monthly data. In adjusting for underlying temporal trends, our modelling approach was able to identify the timing, nature and magnitude of shifts in suicides that followed the announcements of acute-onset economic events. Prior analyses have provided a great deal of vital and timely new information but have been limited by smaller numbers of yearly observations over a single decade or less, or have been restricted to specific suicide subpopulations in Greece.<sup>14 19 46 47</sup> Our analysis was thus in direct response to prior commentaries calling for further processing and analysis of more complete data,<sup>4</sup> systematic, large-scale, longitudinal investigations of the effect of the economic crisis on suicide in Greece,<sup>6 7 9</sup> and the need to investigate whether a link exists between the economic crisis in Greece and suicide.<sup>7 10</sup>

Despite historically having one of the lowest suicide rates in the world,<sup>14</sup> Greece is thought to have been more affected by the global financial downturn than any other European country.<sup>3</sup> The cumulative stress and lowered hopes brought on by an unrelenting and sizeable economic downturn in Greece—including high unemployment rates,<sup>3</sup> household debt, cuts to benefits, entitlements, and pensions, and increasing homelessness—may result in sustained increases in suicide.<sup>1 3 11 19 48 49</sup> Although some have argued that suicide rates in Greece do not correspond to those of unemployment,<sup>7</sup> the connection between economic instability, unemployment, financial strain, loss of status and suicide has been posited as a reasonable explanation in similarly affected countries.<sup>43</sup> Parallel increases in depression and not seeking medical care in the Greek population from 2008 to 2011 also potentially corresponded to those in the recession-suicide connection.<sup>3 48</sup>

Owing to the potential influence of these many other factors, the time-series models we employed were designed to isolate and statistically test the effects of acute, well-publicised austerity and prosperity interruptions-in-time. Through a detrending procedure, our time-series models accounted for general, long-term trends in countless temporal factors that were not directly measured—fluctuations by season, unemployment, psychiatric disorders, changes to the Greek mental healthcare system, etc.

### Study limitations

Several study limitations deserve comment. Prior studies have pointed to the misclassification of suicide as a clear source of bias in national analyses.<sup>14 19–21</sup> This is a particular issue for Greece where religious and other reasons potentially drive under-reporting of suicide.<sup>14</sup> However, it has also been shown that when comparing suicides with the patterns of accidental falls and poisonings in Greece, a large-scale misclassification masking of the true suicide rate is unlikely.<sup>7</sup> The results reported here also appear to be minimally affected by this misclassification bias; our sensitivity analyses accounting for suicide under-reporting maintained the same basic

findings. Future studies might, however, conduct additional sensitivity analyses of suicide misclassification separately for men and women.

A second limitation was the absence of nonfatal self-directed injuries in our analysis.<sup>7</sup> One study showed a 36% increase in the number of people in Greece who reported having attempted suicide.<sup>50</sup> Although only fatal suicide data were available at a national level in Greece, and completed suicides were the main topic of prior debate, the analysis of parasuicides or attempted suicides could have produced different results, especially for certain subgroups, such as females who are known to have higher non-fatal suicide rates than males.<sup>47</sup> In general, our analysis of female suicides in Greece also proceeded with relatively small numbers per month and month-to-month changes of even a few female suicides may be detected as statistically significant. This sensitivity to small fluctuations warrants caution when interpreting our results for female suicide.

More complex statistical time-series methods, such as multivariate ARIMA modelling, could also have been considered to simultaneously model relationships between two or more time series for purposes beyond what we have completed here with univariate interrupted ARIMA modelling, including to further account for unexplained variance in the dependent variable time series in order to more accurately forecast future suicides. However, if the exogenous forces that underlie a long-term trend (eg, unemployment) are relatively constant over time, the constant term in a univariate ARIMA model will adequately represent these forces. Multivariate ARIMA models are particularly useful for forecasting, but they are not required for the testing of the impact of specific interruptions in time as we have done here.<sup>32</sup>

Finally, the significant shifts that we identified may have been related to the austerity measures themselves or could have been related to entirely different, but unmeasured, events that happened in the same months as our interruptions. For instance, the highly publicised pensioner suicide in Athens that we studied coincided with the announcement of the Greek elections in April 2012 that may have simultaneously contributed to economic uncertainty and perhaps the very high levels of suicide in the months that followed. While other such events from other months within our 30-year period that we did not identify may have also been important, we purposely limited the number of interruptions we tested in order to minimise multiple testing issues. Future work could incorporate co-occurring or other monthly economic interruptions, as well as additional suicide data, from later months in later years, to further test our findings.<sup>19</sup>

### Conclusions

Our analysis points to a significant increase in suicides following austerity-related events in Greece. As future austerity measures are considered, greater weight should



be given to the unintended mental health consequences of these measures. Greater attention should also be paid to the public reporting of austerity measures and any subsequent suicide-related events that may follow. Educating the public over these events, while at the same time avoiding sensational language, unnecessarily explicit details and undue repetition of stories, are reasonable approaches to pursue.<sup>45 51–53</sup>

It has been argued that the policies of austerity implemented in Greece have been largely unscientific.<sup>1</sup> Future economic policies, and the public messaging of these policies and related events, may benefit from the findings documented here.

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