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The impact of economic austerity and prosperity on suicide in Greece: a 30-year time-series analysis

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Key words: economic policy, mental health, suicide, injury, time-series

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Abstract

Objectives
To complete a 30-year interrupted time-series analysis of the impact of austerity-related events on the occurrence of suicide across Greece. To also compare the impact of prosperity-related events on suicide across Greece over the same period and investigate suicide under-reporting.

Setting
Greece from January 1, 1983 to December 31, 2012.

Participants
A total of 11,505 suicides, 9,079 by men and 2,426 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 Greek suicide occurred in 2012. The passage of new austerity measures in June 2011 marked the beginning of significant, abrupt and sustained increases in total suicides (+34.7%, $p<0.001$) and male suicides (+18.3%, $p<0.001$). Sensitivity analyses that figured in under-counting of suicides also found a significant, abrupt and sustained increase in June 2011 (+20.5%, $p<0.001$). Greek male suicides also underwent a significant, abrupt and sustained increase in October 2008 when the Greek recession began (+13.9%, $p<0.001$), and an abrupt but temporary increase in April 2012 following a public suicide committed in response to austerity conditions (+29.8%, $p<0.05$). Greek female suicides also underwent an abrupt and sustained increase in May 2011 following austerity-related events (+35.8%, $p<0.05$). No prosperity-related events significantly impacted suicides.

Conclusions
This is the first multi-decade, national analysis of Greek suicide using monthly data. Select austerity-related events in Greece corresponded to statistically significant increases for suicides overall, as well as for suicides among Greek men and women. Limitations of the current study are discussed. The consideration of future austerity measures should give greater weight to the unintended mental health consequences of these measures and public reporting of any subsequent suicide-related events.

Strengths and limitations of this study

Strengths include:

- The first multi-decade, national analysis of Greek suicide using monthly data
- The first analysis of Greek suicide incorporating the latest official data from 2012
- The first robust statistical time-series tests of specific prosperity and austerity-related events on Greek suicide (and not simply yearly analyses of general trends)
- The first robust statistical time-series tests of the abrupt effects of *both* prosperity and austerity-related events on suicide
- The first statistical tests and findings concerning the effect of austerity-related media and press coverage on suicides in Greece
- The first time-series study of suicide to include a sensitivity analyses that figures in under-counting and misclassification of suicides

Limitations include:

- The absence of nonfatal self-directed injuries in our analysis
- Our analysis of Greek female suicides proceeded with relatively small numbers per month
- 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 global economic crisis is the worst since the Great Depression[1,2] and Greece is thought to have been more affected than any other European country.[3] Numerous academic articles and commentaries have been published in recent years speculating about the impact of recent economic austerity measures in Greece.[1,3-5] 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 publicized around the world. Not surprisingly, this publicity and the toxic economic conditions accompanying the austerity measures – high unemployment, inflation, etc. – have also become *the* leading source of public consternation in Greece itself, exacting considerable stress and strain on the Greek public.[1,4] Everyday citizens in Greece face the crisis on a continuous basis 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, labor 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 in Greek suicide 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 skepticism[6,7,37] 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.[4,6-9] To help fill this gap, we undertook a 30-year interrupted time-series analysis of several large and highly publicized 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 analyzed suicides that occurred in Greece from January 1, 1983 to December 31, 2012. Data were assembled as monthly counts of all suicides and monthly counts of suicide separately for males and females. Suicide counts were obtained from death certificates of Greek residents that occurred in Greece over the study period. We included all suicide deaths, regardless of age, since younger individuals who committed suicide, in having the capacity to act to take their own life, also likely had the capacity to perceive how they, individuals they knew, or Greeks generally were impacted by the country's economic situation.

National suicide data were provided by the Hellenic Statistical Authority (ELSTAT), an independent statistical authority that is legislatively charged with safeguarding and

continuously improving the quality of Greece's national statistics and data.[10] The ELSTAT follows European and international standards of statistical practice and data collection.[11] 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.[4,7,12]

In Greece, violent deaths, accidents, and suspected suicides prompt investigative and data collection protocols involving police, local coroners, and public prosecutors. These legal authorities are obliged to perform inquiries and order autopsies by forensic medical doctors at state hospitals.[13] Greek death certificates must be completed before burial, despite forensic investigations that may still be ongoing. Because of this, first-line medical causes of death (or so-called R-codes, ICD-10, R00-R99) are occasionally used as placeholder diagnoses on death certificates[14,15] until the final cause of death (i.e., accident, suicide or homicide) can be amended following further investigation.[16]

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.[17-19] Intentional (to avoid stigma) and unintentional (inability to determine victim intent) reasons may drive under-reporting of suicide in Greece.[12] In particular, the Greek Orthodox Church considers suicide a major sin and condemns suicide victims to be interred without a burial service.[12,20] This has caused some to contend that Greek suicide rates are among the lowest in Europe partly because of under-reporting and misclassification for religious reasons.[12,21]

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).[22] Discrepancies between the two sources indicated that suicidal poisonings, falls, drownings, and hangings likely represented the vast majority of potentially misclassified suicides. All misclassification of suicides were under-counts; in no mechanism of suicide category was there over-counting. Remaining mechanisms of suicide were either very infrequently under-counted (i.e., firearm suicides) or very small in number (i.e., 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. Based on 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 substantial and highly publicized austerity-related events and prosperity-related events that occurred in Greece during the study period and that could be hypothesized to cause an increase or decrease in suicide.[1,3,23-28] These involved well-publicized official economic events by government or other authorities (e.g., passing of legislation, announcements of new government measures, etc.) and highly publicized events by citizens in response to economic events (e.g., strikes, protests, riots, public suicide, etc.). A total of 12 such events were identified from January 1983 to December 2012. Each event was represented in the working dataset as a separate time series variable coded 0 for each month before the event occurred and coded 1 for the month the event occurred and each month thereafter (i.e., a step variable). This allowed us to treat each event as an interruption-in-time for our analyses. Based on these events we also defined a separate prosperity period from September 1997 to August 2004 and a corresponding austerity period from October 2008 to December 2012.

Statistical analyses

We first completed visual inspections and descriptive analyses of the four time series, the interruptions-in-time, and the austerity and prosperity periods. Descriptive analyses included the calculations of means, standard deviations, linear trends and unpaired two-sided t-tests (assuming unequal variances).

We then conducted an interrupted time series analysis using autoregressive integrated moving average (ARIMA) models and transfer functions to test the hypothesized impact of each austerity and prosperity interruption on suicide in Greece. Separately for each of our four time series, this modeling 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 (i.e., a pulse variable coded 1 for the month the event occurred and coded 0 for all other months). This approach allowed us to investigate the form of a given hypothesized 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 Appendix). As the modeling 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 modeling 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.

As part of the ARIMA modeling 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 make it possible to test whether it was different in level, after versus before the onset of each hypothesized interruption. For each of the four time series that were analyzed, 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 modeling, produced white noise residuals.[29,30] SCA WorkBench Version 6.2.1 was used for the analysis (Scientific Computing Associates Corp., Villa Park, Illinois).

Results

In total, 11,505 suicides, 9,079 by men and 2,426 by women, occurred in Greece from January 1, 1983 to December 31, 2012. 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 months of the prosperity period (September 1997 to August 2004) a linear trend analysis showed a small average monthly decrease of -0.01 total suicides per month. By comparison, over the months of the austerity period (October 2008 to December 2012) a linear trend analysis showed an average monthly increase of 0.31 total suicides per month. (Figure 1)

Over the entire 30-year study period, the average monthly number of suicides was 32.0 (+/- 8.5) overall, 25.2 (+/- 7.2) for males, and 6.7 (+/- 3.3) for females. The average monthly number of suicides was 30.3 (+/- 7.8) within the prosperity period and 36.0 (+/- 10.0) within the austerity period ($p<0.001$). Among males, the average monthly number of suicides was 24.3 (+/- 6.7) within the prosperity period and 30.4 (+/- 8.9) within the austerity period ($p<0.001$). Among females, the average monthly number of suicides was 6.0 (+/- 2.6) within the prosperity period and 5.6 (+/- 2.8) within the austerity period.

Interruptions-in-time that were tested

We identified 12 interruptions that may have impacted suicide over the study period, 3 initial prosperity-related events and 9 subsequent austerity-related events. Prosperity-related events began in 1997 when the International Olympic Committee announced that Greece would host the 2004 Olympic Games, through 2000 when Greece was accepted into the Economic and Monetary Union of the European Union, until 2004 when the Olympic Games occurred. The austerity-related events occurred from 2008-2012 with the start of the Greek recession, through various financial bailout packages, riots, strikes, and protests, until a Greek pensioner committed a highly publicized 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 (34.7%) in June 2011, when the Greek government passed a second series of austerity measures ($p=0.0004$). No other austerity

or prosperity-related events corresponded to significant shifts in total suicides. (Table 2, Figure 2a)

The number of suicides by Greek men underwent significant, abrupt and sustained increases of 3.4 average suicides per month (13.9%, p=0.0009) in October 2008, when the Greek recession began, and an additional 5.1 average suicides per month (18.3%, p=0.0002) in June 2011. The number of suicides by Greek men then underwent an abrupt but temporary increase of 9.8 suicides per month (29.8%, p=0.03) in April 2012, gradually returning to the pre-event average (Table 2, Figure 2b). Among Greek females, 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 (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 (+/- 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 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 both total suicides, by 35%, and male suicides, by 18%. 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 Greek females in May 2011.

Relative to other months in which 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 Greeks were opposed to the austerity plan. It also occurred amid multi-day demonstrations, that turned violent as protestors rioted outside the Greek Parliament, and strikes that halted most public services and closed Greek banks.

Differences between the earlier prosperity period and the later austerity period were also clear. No prosperity-related events (Greece entering the EU, hosting the summer Olympics) corresponded with significant reductions in suicide. The prosperity period included the lowest month of suicides in 30 years, whereas the austerity period included the highest months. The prosperity period experienced significantly fewer suicides on average per month and showed almost no trend in suicides, whereas the austerity period showed a relatively steep upward trend in suicides.

Greek men also experienced a significant, abrupt and sustained 14% increase in suicide beginning in October 2008, the same month as the documented start of the recession in

Greece. This well publicized start was marked by the first sustained reduction in the Greek gross domestic product and has pervaded the national public conscience ever since.

Increases in male suicide have been documented in other countries following economic crises. As in these other countries, Greek economic instability primarily affected men who were the predominant family income generators compared with women.[12,17,31,32] The sustained and statistically significant nature of the October 2008 and June 2011 increases in Greek male suicide reveal the systemic and lasting effect that large government austerity programs can have on national economic stability and public health.

Although of borderline statistical significance, Greek men additionally demonstrated a large, but temporary, 30% increase in suicides in April 2012. This increase in Greek male suicide followed the highly publicized 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 hypothesized to create copycat suicide behaviour.[39] 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[4] 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 three months that followed.

Finally, Greek women, 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 Greek female suicide was larger, on a percentage basis, than that for males in 2011. This finding runs counter to previous research showing that economic downturns tend to result in larger increases in male, but not female, suicides.[12,17]

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 skepticism has remained as to whether this relationship is real.[6] These speculations, generally based on government reports, unofficial data, or the media, have placed an increase in Greek suicides anywhere from 17-40%.[1,3-5] One study completed a valuable regression analysis of suicide trends in 54 countries, including Greece, although was limited in that it aggregated suicides by calendar year given the World Health Organization mortality data that were available.[17] This same study suggested further analyses be conducted as monthly

aggregations of suicide, which we have done here for Greece. 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.[31]

This is the first multi-decade, national analysis of Greek suicide using monthly data. In adjusting for underlying temporal trends, our modeling 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.[12,17,33,34] Our analysis was thus in direct response to prior commentaries calling for further processing and analysis of more complete data[4], systematic, large-scale, longitudinal investigations of the effect of the economic crisis on suicide in Greece[6-8], and the need to investigate whether a link exists between the economic crisis in Greece and suicide.[7,9]

Despite historically having one of the lowest suicide rates in the world[12], Greece is thought to have been more affected by the global financial downturn than any other European country.[3] The cumulative stress and lowered hopes brought on by an unrelenting and sizeable economic downturn in Greece – including high unemployment rates[3], severe material deprivation, and increasing homelessness – may result in sustained increases in suicide.[1,3,17,35] Although some have argued that suicide rates in Greece do not correspond with unemployment[7], the connection between economic instability, unemployment, financial strain, loss of status, and suicide has been posited as a reasonable explanation in similarly affected countries.[31] Parallel increases in depression and not seeking medical care in the Greek population from 2008 to 2011 also potentially corresponded with the recession-suicide connection.[3,35]

Because of 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-publicized 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.[12,17-19] This is a particular issue for Greece where religious and other reasons potentially drive under-reporting of suicide.[12] However, it has also been shown that when comparing suicides to the patterns of accidental falls and poisonings in Greece, a large-scale misclassification masking of the true suicide rate is unlikely.[7] 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.

A second limitation was the absence of nonfatal self-directed injuries in our analysis.[7] One study showed a 36% increase in the number of Greeks who reported having attempted suicide.[36] 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 nonfatal suicide rates than males.[34] In general, our analysis of Greek female suicides 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.

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. Events from other months within our 30-year period that we did not identify may have also been important, although in an effort to minimize multiple testing issues we limited the number of interruptions we tested. Future work could incorporate co-occurring or other monthly economic interruptions, as well as additional suicide data, from later months and years, to further test our findings.[17]

Conclusions

Our analysis points to a significant increase in suicides following austerity-related events in Greece. Given these findings, we concur with others that a more robust mental healthcare system that offers more screening, follow-up, and treatment of people with suicidal ideation and accompanying mental health conditions is clearly in order for Greece.[1,6,36] Less expensive telephone and web-based psychotherapies that build long-term relationships between clients and providers also appear to hold promise in reducing suicidal ideation and might be considered.[38] In addition to these potential strategies, enhanced access to everyday activities, goods, and services that are not available in some areas, as well as reduced access to the means of suicide among high-risk populations, are also important strategies to consider.[18,23,33]

While potentially useful, these suicide reduction strategies nevertheless do not directly address the overarching and persistent issue of the austerity-related events themselves. 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 (including the framing of analyses such as this one), while still maintaining open journalism and accurate reporting.[39,40] It has been argued that the policies of austerity implemented in Greece have been largely unscientific.[1] Future economic policies, and the public messaging of these policies and related events, may benefit from the findings documented here.

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)
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 percent reduction in national gross domestic product
December 2008	Austerity-related	Concerns over economy come to a head with highly publicized police shooting of a teenage student that triggers protests and riots
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 organized 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 publicized suicide in the main square of Athens in response to austerity conditions

Table 1. Greek prosperity-related and austerity-related economic events that were tested as time-series interruptions from 1983-2012.

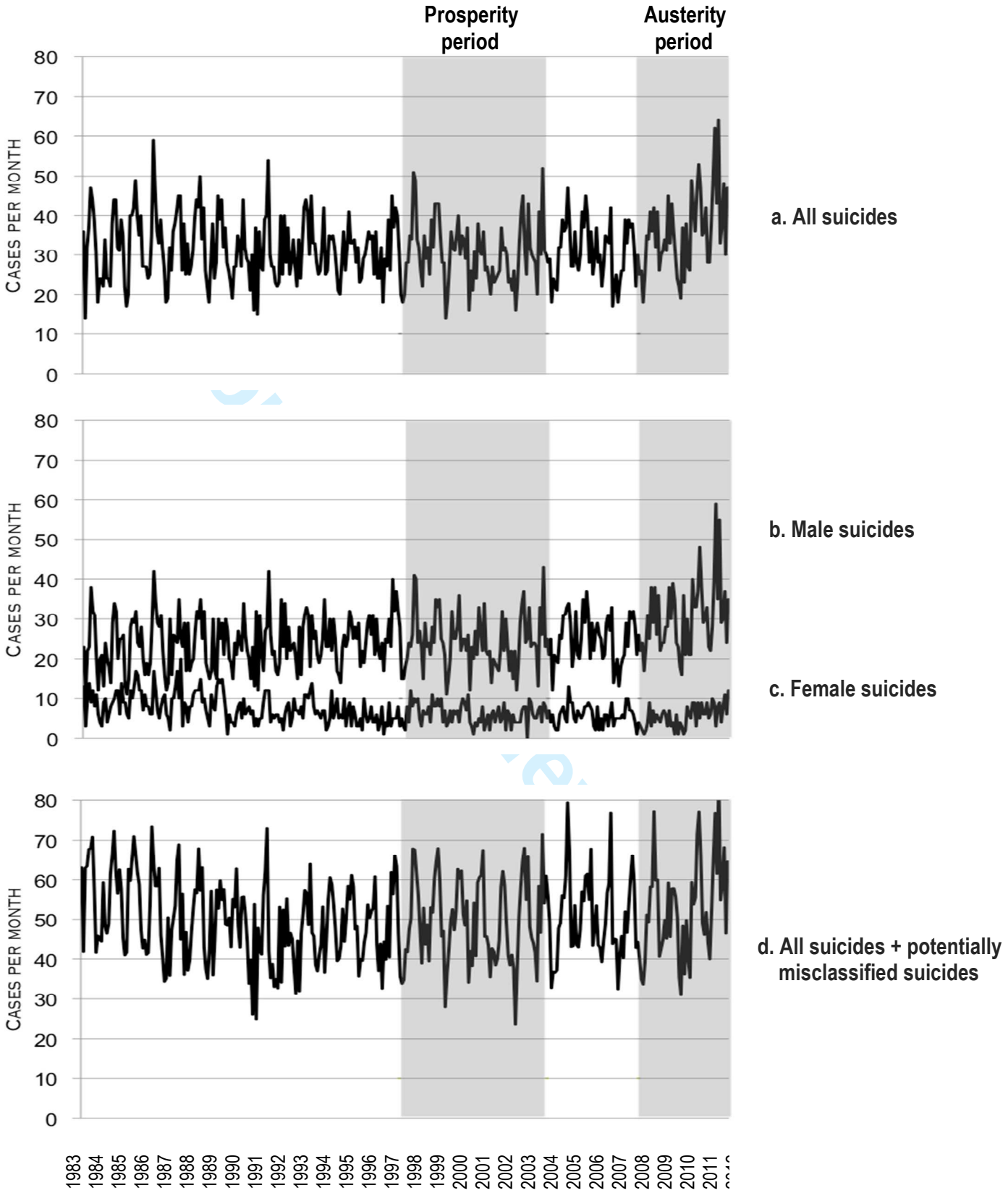

Figure 1. Monthly trends in suicide across Greece for all suicides, gender subcategories of suicide, and potentially misclassified suicides (first grey band denotes "prosperity" period and second grey band denotes "austerity" period).

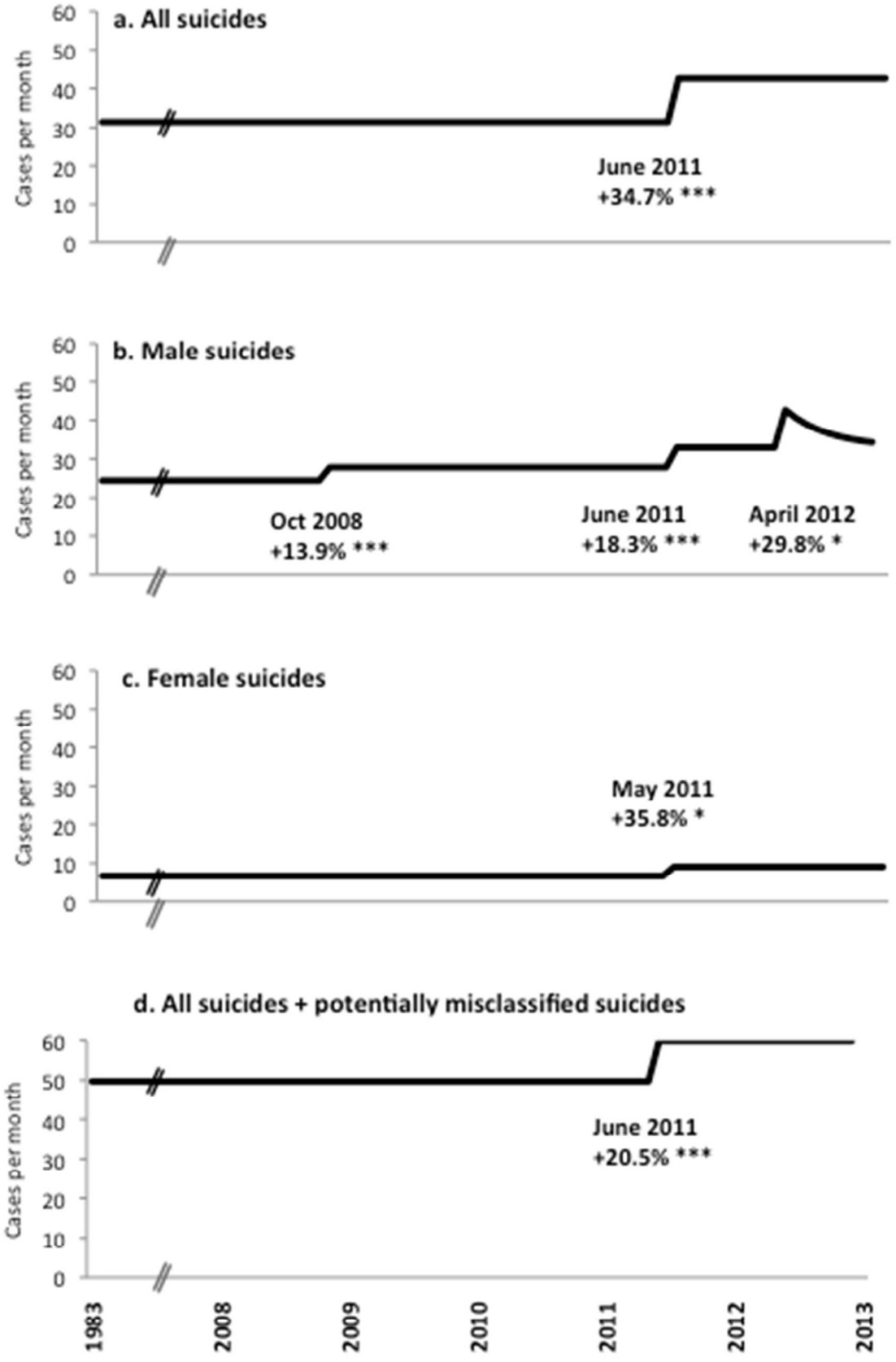

Figure 2. Estimated forms (abrupt sustained, abrupt temporary) and sizes (%) of statistically significant monthly interruptions in four Greek suicide time series analyzed using ARIMA models. * p<0.05, ** p<0.01, *** p<0.001

	All suicides					Male suicides					Female suicides					All suicides + potentially misclassified suicides				
	Abrupt sustained test	Gradual sustained test		Abrupt temporary test		Abrupt sustained test	Gradual sustained test		Abrupt temporary test		Abrupt sustained test	Gradual sustained test		Abrupt temporary test		Abrupt sustained test	Gradual sustained test		Abrupt temporary test	
	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate
September 1997	-.42	.26	.42	2.21	.77	-.16	-.13	.44	.17	.99	.15	.13	.13	.07	.95	.58	.51	.37	.08	.62
June 2000	-1.25	.01	1.07	2.68	.78	.05	.05	.64	.18	.77	.87	-1.79	.94	.71	.45	.92	1.38	.53	.14	.88
August 2004	1.01	.51	.52	-2.67	.42	.71	.27	.67	1.33	.82	.30	.23	.59	.24	.74	.13	-.16	.64	.33	1.01
October 2008	1.95	3.57	.78	4.43	.36	3.44***	5.30	.65	2.01	.03	1.23	-1.63	.32	.43	.68	.14	.07	.82	.04	1.12
December 2008	1.86	1.30	.33	.18	.67	.41	.10	.52	.23	0.54	-1.31	-1.74	.35	-2.55	.82	.34	-.43	.68	-5.51	.56
March 2010	12.31	.23	1.07	.28	.62	-.80	-.69	.44	10.70	.07	-1.30	-0.79	.48	.11	.50	-3.42	-3.02	.32	7.78	.69
May 2010	.04	.10	.59	1.50	.75	-2.08	-1.51	.35	.15	.69	-.82	-.23	.78	.61	.53	-4.62	-1.87	.61	.63	7.28
May 2011	.48	.44	.60	.39	.95	-6.02	-6.26	.24	.01	.83	2.37*	4.31*†	.80*†	3.43	.66	-3.81	-4.27	.40	.07	.94
June 2011	11.20***	5.87	.50	-7.68	.20	5.13***	10.42*†	.79*†	11.86*†	.89*†	-3.19	-5.99	.67	-5.7	.22	10.20***	6.54	.37	-6.30	.14
September 2011	1.24	1.30	.21	7.33	.59	-5.35	-3.06	.75	8.83	.12	1.31	1.83	.55	.40	.89	1.46	1.65	.45	8.98	.47
February 2012	1.69	1.39	.52	-9.68	.46	8.65	-3.06	.75	-9.03	.12	.98	.56	.49	.14	1.42	2.33	.12	1.27	-10.34	.61
April 2012	4.64	2.39	.42	.16	1.70*	-9.03	-9.18	.04	9.81*	.78**	.44	.37	.43	.10	-1.71	6.55	6.67	.01	-.22	.65

All suicide model: ARIMA(0,0,0)(0,1,1).[12] Male suicide model: ARIMA(0,0,0)(0,1,1).[12] Female suicide model: ARIMA(1,0,1)(0,1,1).[12]
All suicide + potentially misclassified suicides model: ARIMA(1,0,1)(0,1,1).[14]
Size: numerator coefficient. Growth rate and decay rate: denominator coefficient. Abrupt sustained 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, Boxes indicate interruptions that were statistically significant and retained in final model.
† The coefficient was statistically significant but produced a poorly fitting estimate of the time series and thus was rejected.

Table 2. Time-series ARIMA modeling results of the impact of austerity-related and prosperity-related events on four monthly Greek suicide time series studied from 1983-2012.

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Appendix. ARIMA models

A) All suicides ARIMA model $(0,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + (1-\theta_{12}B^{12})a_t$$

B) Male suicides ARIMA model $(0,0,0)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + (1-\theta_{12}B^{12})a_t$$

C) Female suicides ARIMA model $(1,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)}a_t$$

D) All suicides + potentially misclassified suicides ARIMA model $(1,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)}a_t$$

FINAL MODELS

$$U_t = W_t + f(I_t)$$

where

$W_t = Y_t - Y_{t-12}$

and $f(I_t)$ is the intervention component of the model

Intervention components

a) Abrupt sustained

$f(I_t) = \omega_0 I_t$

where I_t is a step function such that

I_t=0 prior to the event

=1 thereafter

b) Gradual sustained

$$f(I_t) = \frac{\omega_0}{1-\delta_1 B} I_t$$

where I_t is a step function such that

I_t=0 prior to the event

=1 thereafter

c) Abrupt temporary

$$f(I_t) = \frac{\omega_0}{1-\delta_1 B}(1-B) I_t$$

where I_t is a pulse function such that

$I_t = 0$ prior to the intervention

= 1 at the moment of the intervention

= 0 thereafter

ARIMA Models Including Intervention Component

A) All suicides

$$U_t = \vartheta + (1-\theta_{12}B^{12})a_t + \omega_0 I_{342}$$

B) Male suicides

$$U_t = \vartheta + (1-\theta_{12}B^{12})a_t + \omega_0 I_{310} + \omega_0 I_{342} + \frac{\omega_0}{1-\delta_1 B}(1-B) I_{352}$$

C) Female suicides

$$U_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)} a_t + \omega_0 I_{341}$$

D) All suicides + potentially misclassified suicides

$$U_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)} a_t + \omega_0 I_{353}$$

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

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

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

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 January 1, 1983 to December 31, 2012.

Participants:
A total of 11,505 suicides, 9,079 by men and 2,426 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 (+37.7%, $p<0.001$) and male suicides (+18.5%, $p<0.01$). Sensitivity analyses that figured in under-counting 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 multi-decade, 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

Strengths include:

- The first multi-decade, national analysis of suicide in Greece using monthly data
- The first analysis of suicide in Greece incorporating the latest official data from 2012
- The first robust statistical interrupted time-series study of specific prosperity and austerity-related events on suicide in Greece (and not simply yearly analyses of general trends)
- The first robust statistical time-series tests of the abrupt effects of *both* prosperity and austerity-related events on suicide
- The first statistical tests and findings concerning the effect of austerity-related media and press coverage on suicides in Greece
- The first time-series study of suicide to include a sensitivity analyses that figures in under-counting and misclassification of suicides

Limitations include:

- The absence of nonfatal self-directed injuries in our analysis
- Our analysis of female suicides in Greece proceeded with relatively small numbers per month
- 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[1,2] and Greece is thought to have been more affected than any other European country.[3] Numerous academic articles and commentaries have been published in recent years speculating about the impact of recent economic austerity measures in Greece.[1,3-5] 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 publicized 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.[1,4] 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, labor 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 skepticism[6,7,8] 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.[4,6,7,9,10] To help fill this gap, we undertook a 30-year interrupted time-series analysis of several abrupt and highly publicized 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 analyzed suicides that occurred in Greece from January 1, 1983 to December 31, 2012. Data were assembled as monthly counts of all suicides and monthly counts of suicide separately for males and females. Male-female differences have been demonstrated in prior studies of broad economic trends and suicide in Greece.[11] 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.[12,13] 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.[4,7,14]

In Greece, violent deaths, accidents, and suspected suicides prompt investigative and data collection protocols involving police, local coroners, and public prosecutors. These legal authorities are obliged to perform inquiries and order autopsies by forensic medical doctors at state hospitals.[15] Death certificates in Greece must be completed before burial, despite forensic investigations that may still be ongoing. Because of this, first-line medical causes of death (or so-called R-codes, ICD-10, R00-R99) are occasionally used as placeholder diagnoses on death certificates[16,17] until the final cause of death (i.e., accident, suicide or homicide) can be amended following further investigation.[18]

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.[19-21] Intentional (to avoid stigma) and unintentional (inability to determine victim intent) reasons may drive under-reporting of suicide in Greece.[14] In particular, the Greek Orthodox Church considers suicide a major sin and condemns suicide victims to be interred without a burial service.[14,22] 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.[14,23]

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).[24] Discrepancies between the two sources indicated that suicidal poisonings, falls, drownings, and hangings likely represented the vast majority of potentially misclassified suicides. All misclassification of suicides were under-counts; in no mechanism of suicide category was there over-counting. Remaining mechanisms of suicide were either very infrequently under-counted (i.e., firearm suicides) or very small in number (i.e., 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. Based on 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 publicized and thus likely detected by the Greek public. In being highly publicized and widely known to the general public, these events were hypothesized 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.[1,3,25-30] A total of 12 such events were identified from January 1983 to December 2012. Each event was represented in the working dataset as a separate time series variable coded 0 for each month before the event occurred and coded 1 for the month the event occurred and each month thereafter (i.e., 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, standard deviations, and linear trends.

We then conducted an interrupted time series analysis using autoregressive integrated moving average (ARIMA) models and transfer functions to test the hypothesized impact of each austerity and prosperity interruption on suicide in Greece.[31,32] Separately for each of our four time series, this modeling 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 (i.e., a pulse variable coded 1 for the month the event occurred and coded 0 for all other months). This approach allowed us to investigate the form of a given hypothesized 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 Appendix). As the modeling 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 modeling 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 were used to calculate a percent change in suicide linked to a specific prosperity or austerity interruption-in-time event.

As part of the ARIMA modeling 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 make it possible to test whether it was different in level, after versus before the onset of each hypothesized interruption. For each of the four time series that were analyzed, 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 modeling, produced white noise residuals.[32,33] SCA WorkBench Version 6.2.1 was used for the analysis (Scientific Computing Associates Corp., Villa Park, Illinois).

We used ARIMA modeling for this study because, before testing for the impact of hypothesized interruptions-in-time, the ARIMA modeling 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. Because 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.[31,32] Recent, related works of longer term processes-through-time have involved yearly observations, been less than 50 total observations in time, and have been analyzed using standard regression models.[11] Because our dataset 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 January 1, 1983 to December 31, 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 GDP per capita grew from 4,787 USD in 1983 to 25,309 USD in 2012 and its unemployment rate grew from 7.6% in 1983 to 24.3% in 2012.[34-38]

Over the same 30 year period, 11,505 suicides, 9,079 by men and 2,426 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 males suicides per month, and -0.01 female suicides per month. Over the entire 30-year study period, the average monthly number of suicides was 32.0 (+/- 8.5) overall, 25.2 (+/- 7.2) for males, and 6.7 (+/- 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, 4 initial prosperity-related events and 8 subsequent austerity-related events. Prosperity-

related events began in 1997 when the International Olympic Committee announced that Greece would host the 2004 Olympic Games, through 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 2008-2012 with the start of the Greek recession[39,40], through various financial bailout packages, riots, strikes, and protests, until a Greek pensioner committed a highly publicized 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 (37.7%) in June 2011, when the Greek government passed a second series of austerity measures (p=0.0004). No other austerity 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), that then gradually returned to the pre-event average. Following this, the number of suicides by men in Greece underwent significant, abrupt and 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 females 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 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 (+/- 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 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 both total suicides, by 38%, 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 females in Greece in May 2011.

Relative to other months in which 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, that 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 publicized start was marked by the first sustained reduction in the Greek gross domestic product 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[41,42], this suggests that positive well-publicized economic events can perhaps have a favorable effect on mental health outcomes like suicide.

Increases in male suicide have been documented in other countries following economic crises. As in these other countries, Greek economic instability primarily affected men who were the predominant family income generators compared with women.[14,19,43,44] The sustained and statistically significant nature of the October 2008 and June 2011 increases for male suicides in Greece reveal the systemic and lasting effect that large government austerity programs 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 publicized 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 hypothesized to create copycat suicide behaviour.[45] 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[4] 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 three 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 suicide among women in Greece was larger, on a percentage basis, than that for males in 2011. This finding runs counter to previous research showing that economic downturns tend to result in larger increases in male, but not female, suicides.[14,19]

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 skepticism has remained as to whether this relationship is real.[6] These speculations, generally based on government reports, unofficial data, or the media, have placed an increase of suicides in Greece anywhere from 17-40%.[1,3-5] One study completed a valuable regression analysis of suicide trends in 54 countries, including Greece, although was limited in that it aggregated suicides by calendar year given the World Health Organization mortality data that were available.[19] This same study suggested 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.[11] 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.[43]

This is the first multi-decade, national analysis of suicide in Greece using monthly data. In adjusting for underlying temporal trends, our modeling 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.[14,19,46,47] Our analysis was thus in direct response to prior commentaries calling for further processing and analysis of more complete data[4], systematic, large-scale, longitudinal investigations of the effect of the economic crisis on suicide in Greece[6,7,9], and the need to investigate whether a link exists between the economic crisis in Greece and suicide.[7,10]

Despite historically having one of the lowest suicide rates in the world[14], Greece is thought to have been more affected by the global financial downturn than any other European country.[3] The cumulative stress and lowered hopes brought on by an unrelenting and sizeable economic downturn in Greece – including high unemployment rates[3], household debt, cuts to benefits, entitlements, and pensions, and increasing homelessness – may result in sustained increases in suicide.[1,3,11,19,48,49] Although some have argued that suicide rates in Greece do not correspond with unemployment[7], the connection between economic

instability, unemployment, financial strain, loss of status, and suicide has been posited as a reasonable explanation in similarly affected countries.[43] Parallel increases in depression and not seeking medical care in the Greek population from 2008 to 2011 also potentially corresponded with the recession-suicide connection.[3,48]

Because of 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-publicized 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.[14,19-21] This is a particular issue for Greece where religious and other reasons potentially drive under-reporting of suicide.[14] However, it has also been shown that when comparing suicides to the patterns of accidental falls and poisonings in Greece, a large-scale misclassification masking of the true suicide rate is unlikely.[7] 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.[7] One study showed a 36% increase in the number of people in Greece who reported having attempted suicide.[50] 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 nonfatal suicide rates than males.[47] 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 modeling, 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 modeling, 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 (e.g. 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.[32]

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 minimize 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.[19]

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. Taking the opportunity to educate 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.[45,51-53]

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

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 percent 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 organized 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 publicized suicide in the main square of Athens in response to austerity conditions

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

	All suicide					Male suicide					Female suicide					All suicide + 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	
	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate
September 1997	-.42	.26	.42	2.21	.77	-.16	-.13	.44	.17	.99	.15	.13	.13	.07	.95	.58	.51	.37	.08	.62
June 2000	-1.25	.01	1.07	2.68	.78	.05	.05	.64	.18	.77	.87	-1.79	.94	.71	.45	.92	1.38	.53	.14	.88
January 2002	-.44	-.51	-.18	-.38	.83	-.37	-.77	-.46	-6.62*	.84**	-.28	-.21	.53	2.09	.06	-1.12	-3.41	.91	1.24	.45
August 2004	1.01	.51	.52	-2.67	.42	.71	.27	.67	1.33	.82	.30	.23	.59	.24	.74	.13	-.16	.64	.33	1.01
October 2008	1.95	3.57	.78	4.43	.36	3.24**	5.30	.65	2.01	.03	1.23	-1.63	.32	.43	.68	.14	.07	.82	.04	1.12
March 2010	12.31	.23	1.07	.28	.62	-.80	-.69	.44	10.70	.07	-1.30	-0.79	.48	.11	.50	-3.42	-3.02	.32	7.78	.69
May 2010	.04	.10	.59	1.50	.75	-2.08	-1.51	.35	.15	.69	-.82	-.23	.78	.61	.53	-4.62	-1.87	.61	.63	7.28
May 2011	.48	.44	.60	.39	.95	-6.02	-6.26	.24	.01	.83	2.37*	4.31*†	.80*†	3.43	.66	-3.81	-4.27	.40	.07	.94
June 2011	11.20**	5.87	.50	-7.68	.20	5.16**	10.42*†	.79*†	11.86*†	.89*†	-3.19	-5.99	.67	-5.7	.22	10.20**	6.54	.37	-6.30	.14
September 2011	1.24	1.30	.21	7.33	.59	-5.35	-3.06	.75	8.83	.12	1.31	1.83	.55	.40	.89	1.46	1.65	.45	8.98	.47
February 2012	1.69	1.39	.52	-9.68	.46	8.65	-3.06	.75	-9.03	.12	.98	.56	.49	.14	1.42	2.33	.12	1.27	-10.34	.61
April 2012	4.64	2.39	.42	.16	1.70*	-9.03	-9.18	.04	9.81*	.78**	.44	.37	.43	.10	-1.71	6.55	6.67	.01	-.22	.65

Table 2. Time-series ARIMA modeling results of the impact of austerity-related and prosperity-related events on four monthly suicide time series studied in Greece from 1983-2012.

FOOTNOTE

All suicide model: 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 suicide + 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<0.001 Boxes indicate interruptions that were statistically significant and retained in final model.

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

Contributorship statement

Dr. Branas conceived and oversaw the study, obtained data, conducted analyses, and wrote the manuscript. Dr. Kastanaki conceived the study, obtained data, and wrote the manuscript. Dr. Michalodimitrakis helped conceive the study, obtained data and reviewed the manuscript. Dr. Tzougas helped obtain data and reviewed the manuscript. Dr. Kranioti helped obtain data and reviewed the manuscript. Dr. Theodorakis helped conceive the study and reviewed the manuscript. Dr. Carr helped conceive the study and write the manuscript. Dr. Wiebe conceived and oversaw the study, conducted analyses, and wrote the manuscript.

Each author listed contributed to the research and the final document and each author fulfilled all three of the ICMJE guidelines for authorship: 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published.

The authors have no competing interests.

All authors have completed the Unified Competing Interest form and declare: no support from any organization for the submitted work; no financial relationships with any organizations that might have an interest in the submitted work in the previous three years, and no other relationships or activities that could appear to have influenced the submitted work.

Transparency declaration: the lead author (the manuscript's guarantor) affirms that the manuscript is an honest, accurate, and transparent account of the study being reported; that no important aspects of the study have been omitted; and that any discrepancies from the study as planned (and, if relevant, registered) have been explained.

Data sharing statement: No additional data available.

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FIGURE LEGENDS

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

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

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Each author listed contributed to the research and the final document and each author fulfilled all three of the ICMJE guidelines for authorship: 1) substantial contributions to conception and design, acquisition of data, or analysis and interpretation of data; 2) drafting the article or revising it critically for important intellectual content; and 3) final approval of the version to be published.

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Key words: economic policy, mental health, suicide, injury, time-series

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

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 January 1, 1983 to December 31, 2012.

Participants:
A total of 11,505 suicides, 9,079 by men and 2,426 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 (+37.7%, $p<0.001$) and male suicides (+18.5%, $p<0.01$). Sensitivity analyses that figured in under-counting 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 multi-decade, 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

Strengths include:

- The first multi-decade, national analysis of suicide in Greece using monthly data
- The first analysis of suicide in Greece incorporating the latest official data from 2012
- The first robust statistical interrupted time-series study of specific prosperity and austerity-related events on suicide in Greece (and not simply yearly analyses of general trends)
- The first robust statistical time-series tests of the abrupt effects of *both* prosperity and austerity-related events on suicide
- The first statistical tests and findings concerning the effect of austerity-related media and press coverage on suicides in Greece
- The first time-series study of suicide to include a sensitivity analyses that figures in under-counting and misclassification of suicides

Limitations include:

- The absence of nonfatal self-directed injuries in our analysis
- Our analysis of female suicides in Greece proceeded with relatively small numbers per month
- 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[1,2] and Greece is thought to have been more affected than any other European country.[3] Numerous academic articles and commentaries have been published in recent years speculating about the impact of recent economic austerity measures in Greece.[1,3-5] 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 publicized 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.[1,4] 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, labor 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 skepticism[6,7,8] 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.[4,6,7,9,10] To help fill this gap, we undertook a 30-year interrupted time-series analysis of several abrupt and highly publicized 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 analyzed suicides that occurred in Greece from January 1, 1983 to December 31, 2012. Data were assembled as monthly counts of all suicides and monthly counts of suicide separately for males and females. Male-female differences have been demonstrated in prior studies of broad economic trends and suicide in Greece.[11] 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.[12,13] 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.[4,7,14]

In Greece, violent deaths, accidents, and suspected suicides prompt investigative and data collection protocols involving police, local coroners, and public prosecutors. These legal authorities are obliged to perform inquiries and order autopsies by forensic medical doctors at state hospitals.[15] Death certificates in Greece must be completed before burial, despite forensic investigations that may still be ongoing. Because of this, first-line medical causes of death (or so-called R-codes, ICD-10, R00-R99) are occasionally used as placeholder diagnoses on death certificates[16,17] until the final cause of death (i.e., accident, suicide or homicide) can be amended following further investigation.[18]

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.[19-21] Intentional (to avoid stigma) and unintentional (inability to determine victim intent) reasons may drive under-reporting of suicide in Greece.[14] In particular, the Greek Orthodox Church considers suicide a major sin and condemns suicide victims to be interred without a burial service.[14,22] 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.[14,23]

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).[24] Discrepancies between the two sources indicated that suicidal poisonings, falls, drownings, and hangings likely represented the vast majority of potentially misclassified suicides. All misclassification of suicides were under-counts; in no mechanism of suicide category was there over-counting. Remaining mechanisms of suicide were either very infrequently under-counted (i.e., firearm suicides) or very small in number (i.e., 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. Based on 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 publicized and thus likely detected by the Greek public. In being highly publicized and widely known to the general public, these events were hypothesized 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.[1,3,25-30] A total of 12 such events were identified from January 1983 to December 2012. Each event was represented in the working dataset as a separate time series variable coded 0 for each month before the event occurred and coded 1 for the month the event occurred and each month thereafter (i.e., 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, standard deviations, and linear trends.

We then conducted an interrupted time series analysis using autoregressive integrated moving average (ARIMA) models and transfer functions to test the hypothesized impact of each austerity and prosperity interruption on suicide in Greece.[31,32] Separately for each of our four time series, this modeling 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 (i.e., a pulse variable coded 1 for the month the event occurred and coded 0 for all other months). This approach allowed us to investigate the form of a given hypothesized 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 Appendix). As the modeling 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 modeling 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 were used to calculate a percent change in suicide linked to a specific prosperity or austerity interruption-in-time event.

As part of the ARIMA modeling 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 make it possible to test whether it was different in level, after versus before the onset of each hypothesized interruption. For each of the four time series that were analyzed, 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 modeling, produced white noise residuals.[32,33] SCA WorkBench Version 6.2.1 was used for the analysis (Scientific Computing Associates Corp., Villa Park, Illinois).

We used ARIMA modeling for this study because, before testing for the impact of hypothesized interruptions-in-time, the ARIMA modeling 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. Because 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.[31,32] Recent, related works of longer term processes-through-time have involved yearly observations, been less than 50 total observations in time, and have been analyzed using standard regression models.[11] Because our dataset 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 January 1, 1983 to December 31, 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 GDP per capita grew from 4,787 USD in 1983 to 25,309 USD in 2012 and its unemployment rate grew from 7.6% in 1983 to 24.3% in 2012.[34-38]

Over the same 30 year period, 11,505 suicides, 9,079 by men and 2,426 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 males suicides per month, and -0.01 female suicides per month. Over the entire 30-year study period, the average monthly number of suicides was 32.0 (+/- 8.5) overall, 25.2 (+/- 7.2) for males, and 6.7 (+/- 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, 4 initial prosperity-related events and 8 subsequent austerity-related events. Prosperity-

related events began in 1997 when the International Olympic Committee announced that Greece would host the 2004 Olympic Games, through 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 2008-2012 with the start of the Greek recession[39,40], through various financial bailout packages, riots, strikes, and protests, until a Greek pensioner committed a highly publicized 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 (37.7%) in June 2011, when the Greek government passed a second series of austerity measures (p=0.0004). No other austerity 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), that then gradually returned to the pre-event average. Following this, the number of suicides by men in Greece underwent significant, abrupt and 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 females 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 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 (+/- 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 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 both total suicides, by 38%, 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 females in Greece in May 2011.

Relative to other months in which 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, that 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 publicized start was marked by the first sustained reduction in the Greek gross domestic product 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[41,42], this suggests that positive well-publicized economic events can perhaps have a favorable effect on mental health outcomes like suicide.

Increases in male suicide have been documented in other countries following economic crises. As in these other countries, Greek economic instability primarily affected men who were the predominant family income generators compared with women.[14,19,43,44] The sustained and statistically significant nature of the October 2008 and June 2011 increases for male suicides in Greece reveal the systemic and lasting effect that large government austerity programs 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 publicized 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 hypothesized to create copycat suicide behaviour.[45] 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[4] 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 three 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 suicide among women in Greece was larger, on a percentage basis, than that for males in 2011. This finding runs counter to previous research showing that economic downturns tend to result in larger increases in male, but not female, suicides.[14,19]

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 skepticism has remained as to whether this relationship is real.[6] These speculations, generally based on government reports, unofficial data, or the media, have placed an increase of suicides in Greece anywhere from 17-40%.[1,3-5] One study completed a valuable regression analysis of suicide trends in 54 countries, including Greece, although was limited in that it aggregated suicides by calendar year given the World Health Organization mortality data that were available.[19] This same study suggested 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.[11] 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.[43]

This is the first multi-decade, national analysis of suicide in Greece using monthly data. In adjusting for underlying temporal trends, our modeling 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.[14,19,46,47] Our analysis was thus in direct response to prior commentaries calling for further processing and analysis of more complete data[4], systematic, large-scale, longitudinal investigations of the effect of the economic crisis on suicide in Greece[6,7,9], and the need to investigate whether a link exists between the economic crisis in Greece and suicide.[7,10]

Despite historically having one of the lowest suicide rates in the world[14], Greece is thought to have been more affected by the global financial downturn than any other European country.[3] The cumulative stress and lowered hopes brought on by an unrelenting and sizeable economic downturn in Greece – including high unemployment rates[3], household debt, cuts to benefits, entitlements, and pensions, and increasing homelessness – may result in sustained increases in suicide.[1,3,11,19,48,49] Although some have argued that suicide rates in Greece do not correspond with unemployment[7], the connection between economic

instability, unemployment, financial strain, loss of status, and suicide has been posited as a reasonable explanation in similarly affected countries.[43] Parallel increases in depression and not seeking medical care in the Greek population from 2008 to 2011 also potentially corresponded with the recession-suicide connection.[3,48]

Because of 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-publicized 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.[14,19-21] This is a particular issue for Greece where religious and other reasons potentially drive under-reporting of suicide.[14] However, it has also been shown that when comparing suicides to the patterns of accidental falls and poisonings in Greece, a large-scale misclassification masking of the true suicide rate is unlikely.[7] 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.[7] One study showed a 36% increase in the number of people in Greece who reported having attempted suicide.[50] 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 nonfatal suicide rates than males.[47] 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 modeling, 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 modeling, 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 (e.g. 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.[32]

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 minimize 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.[19]

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. Taking the opportunity to educate 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.[45,51-53]

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

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 percent 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 organized 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 publicized suicide in the main square of Athens in response to austerity conditions

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

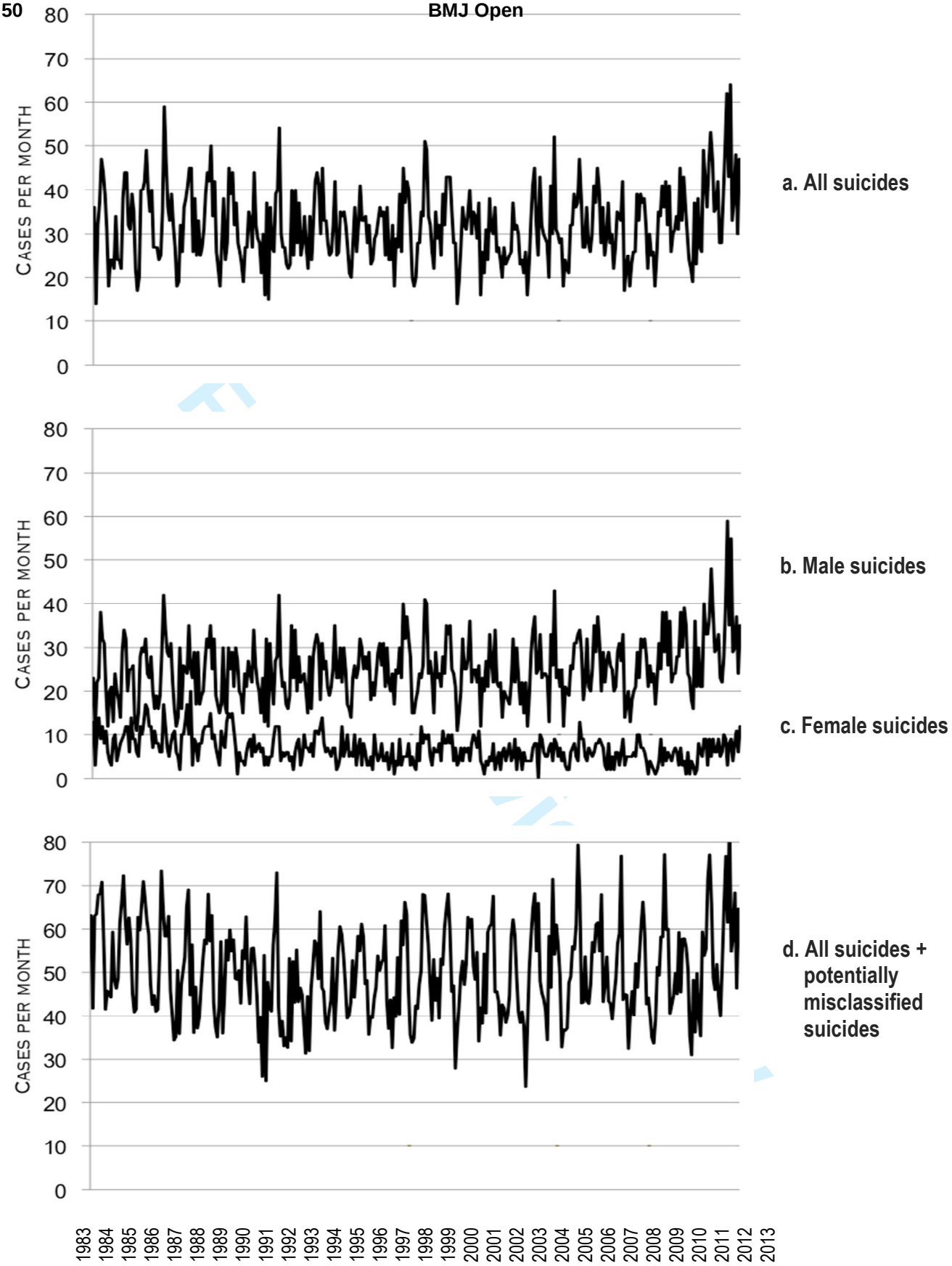

Figure 1. Monthly trends in suicide across Greece for all suicides, gender subcategories of suicide, and potentially misclassified suicides.

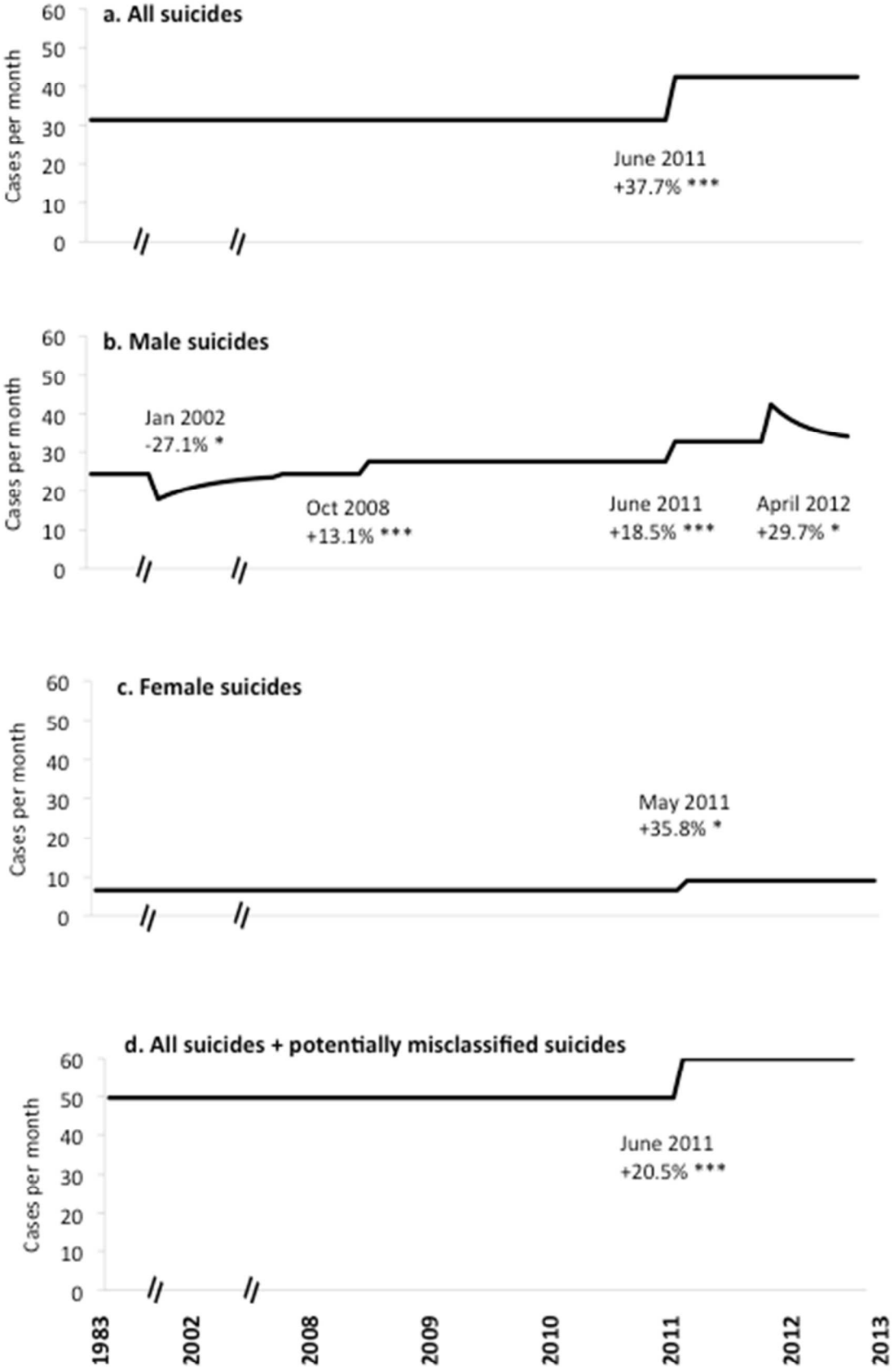

Figure 2. Estimated forms (abrupt sustained, abrupt temporary) and magnitudes (%) of statistically significant monthly interruptions in four Greek suicide time series.
* p<0.05, ** p<0.01, *** p<0.001

	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	
	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate	Size	Size	Growth rate	Size	Decay rate
September 1997	-.42	.26	.42	2.21	.77	-.16	-.13	.44	.17	.99	.15	.13	.13	.07	.95	.58	.51	.37	.08	.62
June 2000	-1.25	.01	1.07	2.68	.78	.05	.05	.64	.18	.77	.87	-1.79	.94	.71	.45	.92	1.38	.53	.14	.88
January 2002	-.44	-.51	-.18	-.38	.83	-.37	-.77	-.46	-6.62*	.84**	-.28	-.21	.53	2.09	.06	-1.12	-3.41	.91	1.24	.45
August 2004	1.01	.51	.52	-2.67	.42	.71	.27	.67	1.33	.82	.30	.23	.59	.24	.74	.13	-.16	.64	.33	1.01
October 2008	1.95	3.57	.78	4.43	.36	3.24***	5.30	.65	2.01	.03	1.23	-1.63	.32	.43	.68	.14	.07	.82	.04	1.12
March 2010	12.31	.23	1.07	.28	.62	-.80	-.69	.44	10.70	.07	-1.30	-0.79	.48	.11	.50	-3.42	-3.02	.32	7.78	.69
May 2010	.04	.10	.59	1.50	.75	-2.08	-1.51	.35	.15	.69	-.82	-.23	.78	.61	.53	-4.62	-1.87	.61	.63	7.28
May 2011	.48	.44	.60	.39	.95	-6.02	-6.26	.24	.01	.83	2.37*	4.31*†	.80*†	3.43	.66	-3.81	-4.27	.40	.07	.94
June 2011	11.20***	5.87	.50	-7.68	.20	5.16***	10.42*†	.79*†	11.86*†	.89*†	-3.19	-5.99	.67	-5.68	.22	10.20***	6.54	.37	-6.30	.14
September 2011	1.24	1.30	.21	7.33	.59	-5.35	-3.06	.75	8.83	.12	1.31	1.83	.55	.40	.89	1.46	1.65	.45	8.98	.47
February 2012	1.69	1.39	.52	-9.68	.46	8.65	-3.06	.75	-9.03	.12	.98	.56	.49	.14	1.42	2.33	.12	1.27	-10.34	.61
April 2012	4.64	2.39	.42	.16	1.70*	-9.03	-9.18	.04	9.81*	.78**	.44	.37	.43	.10	-1.71	6.55	6.67	.01	-.22	.65

All suicide model: 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 suicide + 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 Boxes indicate interruptions that were statistically significant and retained in final model.

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

Table 2. Time-series ARIMA modeling results of the impact of austerity-related and prosperity-related events on four monthly suicide time series studied in Greece from 1983-2012.

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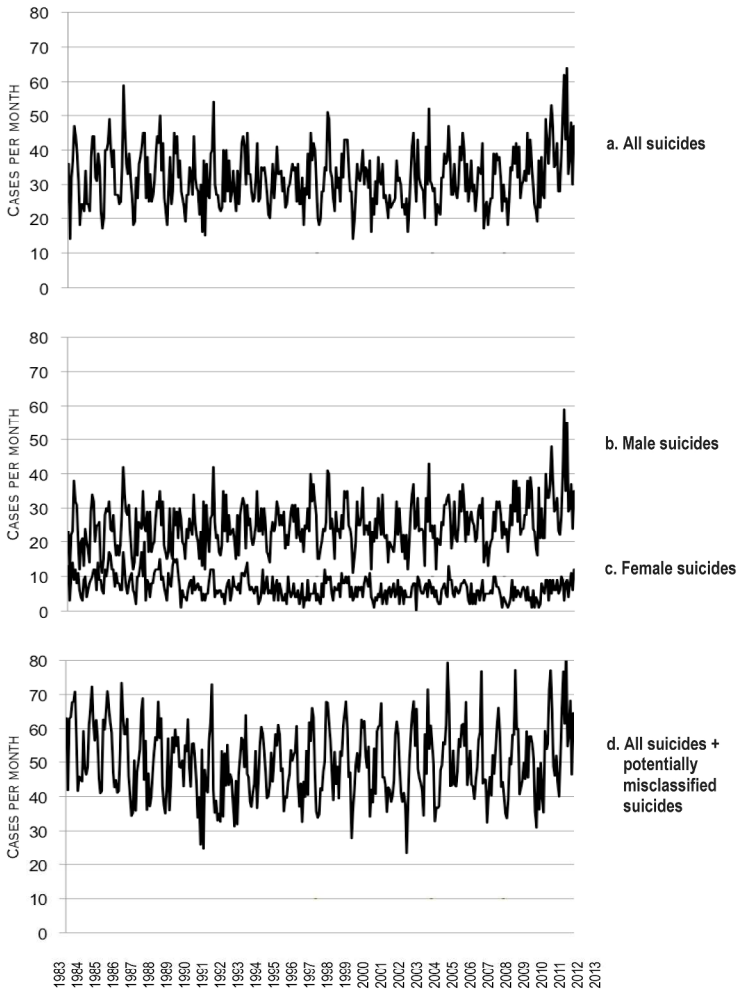

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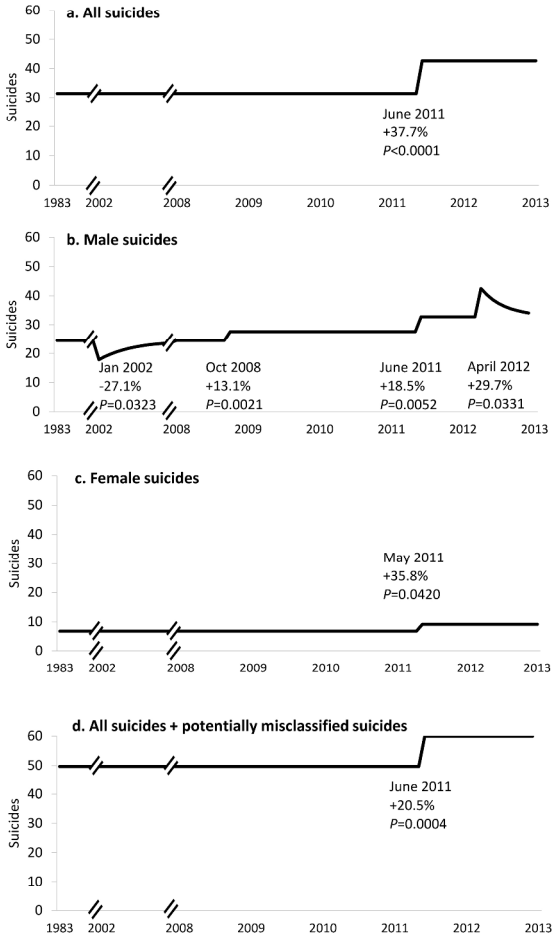

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Appendix. ARIMA models

A) All suicides ARIMA model $(0,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + (1-\theta_{12}B^{12})a_t$$

B) Male suicides ARIMA model $(0,0,0)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + (1-\theta_{12}B^{12})a_t$$

C) Female suicides ARIMA model $(1,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)}a_t$$

D) All suicides + potentially misclassified suicides ARIMA model $(1,0,1)(0,1,1)_{12}$

$$(1-B^{12})y_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)}a_t$$

FINAL MODELS

$$U_t = W_t + f(I_t)$$

where

$W_t = Y_t - Y_{t-12}$

and $f(I_t)$ is the intervention component of the model

Intervention components

a) Abrupt sustained

$f(I_t) = \omega_0 I_t$

where I_t is a step function such that

I_t=0 prior to the event

=1 thereafter

b) Gradual sustained

$$f(I_t) = \frac{\omega_0}{1-\delta_1 B} I_t$$

where I_t is a step function such that

I_t=0 prior to the event

=1 thereafter

c) Abrupt temporary

$$f(I_t) = \frac{\omega_0}{1-\delta_1 B}(1-B) I_t$$

where I_t is a pulse function such that

$I_t = 0$ prior to the intervention

= 1 at the moment of the intervention

= 0 thereafter

ARIMA Models Including Intervention Component

A) All suicides

$$U_t = \vartheta + (1-\theta_{12}B^{12})a_t + \omega_0 I_{342}$$

B) Male suicides

$$U_t = \vartheta + (1-\theta_{12}B^{12})a_t + \omega_0 I_{310} + \omega_0 I_{342} + \frac{\omega_0}{1-\delta_1 B}(1-B) I_{352}$$

C) Female suicides

$$U_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)} a_t + \omega_0 I_{341}$$

D) All suicides + potentially misclassified suicides

$$U_t = \vartheta + \frac{(1-\theta_1 B)(1-\theta_{12}B^{12})}{(1-\phi_1 B)} a_t + \omega_0 I_{353}$$

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