



Worldwide trends in suicide mortality from 1990 to 2015 with a focus on the global recession time frame

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Abstract

Objectives To report worldwide trends in suicide mortality during a period that covers 7 years after the 2008 global crisis.

Methods We performed a time trend analysis with joinpoint regression.

Results Over the 2000s, suicide mortality decreased with the largest declines observed in some Eastern European countries. The downward trends were followed by an increase in concomitance with the 2008 global crisis in some countries, including Greece (annual percentage change = + 6 in men and + 11.8 in women), the Netherlands (+ 4.2 in men and + 4.0 in women), and the UK (+ 1.6 in men), while the pre-crisis downward trends stopped in Germany, Italy, and Spain. The joinpoint analysis also revealed long-term rises in Brazil (+ 0.8 since 1990 in men and + 1.8 since 1999 in women), Mexico (+ 1.3 since 1995 in men and + 3.6 since 1990 in women), the USA (+ 1.7 since 2005 in men and + 4.2 since 2010 in women), and Australia (+ 1.8 in men and + 3.7 in women, since 2006 in both sexes).

Conclusions Despite downward trends in several areas of the world, in some countries suicide rates increased since the 2008 global crisis.

Keywords Suicide · Mortality · Trends · Financial crisis

Introduction

In 2015, suicide was the second cause of death worldwide among people aged 15–29 years, and the seventh among those aged 30–49 years (WHO 2017). Data up to 1999 showed different trends by country, with declining mortality in Eastern Europe, in Japan over the 1990s for both sexes, in the USA, and the rest of Europe for women, while

suicide mortality increased sharply in the Russian Federation (Levi et al. 2003).

Mental and behavioural disorders and chronic pain, along with alcohol and drug abuse, are the main risk factors for suicide (Kerr et al. 2011; Chesney et al. 2014; Hassett et al. 2014; Walker et al. 2017). Financial difficulties and psycho-social factors also play a role and may in turn influence the onset of mental and behavioural disorders contributing to suicide (Yur'yev et al. 2013).

During economic downturns, increases in suicide have been reported repeatedly and explained as a consequence of the stressful environment following the economic recession, with increased unemployment rates and a general feeling of job insecurity (Laanani et al. 2015). After the 2008 global crisis, the unemployment rate surged in some countries with a threefold increase in Greece and Spain and a twofold increase in Italy, the Netherlands, and the USA (International Labour Organization (ILO) 2018). While in the USA, the figure approached the pre-crisis rate a few years after the crisis, unemployment rates remained substantially high in the other European countries.

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Fiscal austerity and cuts in government expenditures generally reduce the funding available for social programmes. Fiscal austerity negatively affected suicide mortality in Greece, Ireland, and most Southern Europe, with long-lasting effects (Antonakakis and Collins 2015; Economou et al. 2016).

A few studies, carried out after the 2008 global financial crisis, reported an excess in mortality from suicide as compared to pre-crisis trends with sizeable differences across countries (Chang et al. 2013; Laanani et al. 2015; Nordt et al. 2015). The increase rate in suicide tended to be higher in some countries, including Greece, the Netherlands, the UK, and most of the Eastern European countries (Chang et al. 2013).

Compared to pre-crisis trend, Chang et al. estimated an overall excess of 5124 suicide deaths in 2009 among men in 54 countries, corresponding to a 3.3% increase, while no change was reported in women. However, only one-third to one-fifth of this excess has been ascribed to changes in unemployment rate or to economic fluctuations over the period (Barr et al. 2012; Reeves et al. 2014; Harper et al. 2015). This discrepancy can be partly attributed to the violation of the linearity assumption when pre-crisis trend was used to calculate expected deaths during and after the crisis, but also to other unmeasured factors related to the psychological distress induced by the financial crisis that may have increased the incidence of major depressive and anxiety disorders (Katikireddi et al. 2012; Harper et al. 2015).

Most studies, published so far, covered a limited period after the crisis (1–3 years) and could not evaluate the long-term effects in countries that are still enduring the negative effects of the global crisis. However, the stressful environment induced by the financial crisis impaired mental health (Katikireddi et al. 2012; Roca et al. 2013; Economou et al. 2016) and in turn may result in increased suicide mortality in the long run.

This study describes mortality trends from suicide in 58 countries across Europe, America, and Australasia with a focus on the potential consequences of the 2008 global crisis.

Methods

Data source and management

We extracted suicide deaths from official death certification data over the period 1990–2015, from the World Health Organization (WHO) database (WHO Statistical Information System). From the same WHO database, we extracted estimates of the resident populations, based on official censuses. For American countries, we extracted the

populations from the Pan American Health Organization (PAHO), since the WHO data were missing for several years.

We considered 58 countries worldwide according to population size and their mortality coverage. We included countries with more than one million inhabitants with consistent data and mortality data coverage greater than 85%. These included 33 countries from Europe, 15 from America, and 10 from Australasia.

We classified suicide deaths for all calendar years and countries recoding the three successive Revisions of the International Classification of Diseases used over the studied period (ICD-8: E950-959, ICD-9: E950-959, and ICD-10: X60-X84, Y87.0) according to the Tenth Revision of the ICD.

Data analysis

Using matrices of certified deaths and resident populations, we computed age-specific mortality rates per 100,000 person-years for each subsequent quinquennium of age (from 0–4 to 80+ years), sex, and calendar year by dividing the number of deaths by the resident populations; the resulting figure was then multiplied per 100,000. In order to compare rates for different countries or periods, we then computed age-standardized mortality rates at all ages, and for three age groups (i.e. 15–24, 25–64, and 65+ years), using the direct method on the basis of the world standard population (Estève et al. 1994).

In a subset of 28 selected major countries with populations over 10 million inhabitants, we performed joinpoint regression analysis, over the period 1990–2015, to identify the calendar years when a change in the linear slope (on a log scale) of the temporal trend occurred (National Cancer Institute; Kim et al. 2000). The analysis starts with a minimum number of joinpoints and tests whether a change in the trend was statistically significant by testing more joinpoints up to the maximum number. In our analysis, we tested from a minimum of zero joinpoints (i.e. a straight line) to a maximum of three joinpoints (four segments). We then computed the estimated annual percentage change (APC) for each identified trend by fitting a regression line to the natural logarithm of the rates using the calendar year as a regressor variable. Thus, the APC indicates the annual percentage change in suicide mortality rate over each identified trend.

Results

Table 1 (for men) and Table 2 (for women) give the age-standardized mortality rates from suicide per 100,000 person-years by country and three-year period, the annual average number of deaths occurred in the latest three-year

Table 1 Age-standardized (world population) mortality rates (ASMRs) from suicide (per 100,000) in men, average annual deaths of the latest period, and percentage changes, in 28 selected major countries worldwide by three-year calendar period (2004–2015)

	ASMRs				Average annual deaths (Latest period)	Percentage changes		
	(Pre-crisis)	(Around crisis)	(Post-crisis)	(Latest period)		2013–15 vs. 2004–06	2007–09 vs. 2004–06	2010–12 vs. 2007–09
	2004–06	2007–09	2010–12	2013–15				
<i>Europe</i>								
Belgium	20.53	19.39	19.54	17.06	1259	– 16.9	– 5.6	0.8
Czech Republic	18.50	16.85	18.81	17.19	1202	– 7.1	– 8.9	11.6
France	18.60	17.77	17.29	15.43	6671	– 17.0	– 4.5	– 2.7
Germany	12.95	11.75	12.03	11.84	7342	– 8.6	– 9.3	2.4
Greece	4.01	3.95	4.88	5.79	432	44.4	– 1.5	23.5
Italy	6.86	6.84	7.30	6.90	3053	0.6	– 0.3	6.7
Kazakhstan	44.06	39.82	32.66	29.03	2581	– 34.1	– 9.6	– 18.0
The Netherlands	10.09	9.50	10.77	11.52	1277	14.2	– 5.9	13.4
Poland	22.14	21.30	22.95	21.23	5056	– 4.1	– 3.8	7.8
Portugal	.	8.14	8.60	9.99	813	.	.	5.7
Romania	16.62	15.29	16.51	14.85	1934	– 10.7	– 8.0	8.0
Russian Federation	46.90	39.29	31.34	28.68	23,794	– 38.9	– 16.2	– 20.2
Spain	8.09	7.71	7.22	8.06	2760	– 0.4	– 4.7	– 6.4
Ukraine	32.40	29.71	27.52	24.46	6282	– 24.5	– 8.3	– 7.4
The UK	8.54	8.63	8.81	9.43	3654	10.4	1.1	2.1
<i>America</i>								
Argentina	11.69	10.94	10.93	10.72	2443	– 8.3	– 6.4	– 0.1
Brazil	6.82	7.08	7.10	7.47	8358	9.5	3.8	0.3
Chile	16.58	17.71	16.32	14.14	1443	– 14.7	6.8	– 7.9
Colombia	7.87	7.7	6.98	6.95	1755	– 11.7	– 2.2	– 9.4
Cuba	15.13	14.13	15.33	14.31	1186	– 5.4	– 6.6	8.5
Mexico	6.42	6.58	6.88	7.39	4855	15.1	2.5	4.6
Venezuela	6.33	4.92	4.27	3.26	500	– 48.5	– 22.3	– 13.2
Canada	14.08	13.77	13.63	13.58	3033	– 3.6	– 2.2	– 1.0
The USA	14.78	15.50	16.48	17.04	32,993	15.3	4.9	6.3
<i>Australasia</i>								
Japan	25.44	25.52	23.49	20.40	17,002	– 19.8	0.3	– 8.0
Philippines	3.43	3.27	3.85	.	1732	.	– 4.7	17.7
Republic of Korea	27.74	28.64	31.41	27.74	9785	0.0	3.2	9.7
Australia	13.81	13.81	13.91	15.28	2127	10.6	0.0	0.7

Note: Data were not available for France in 2015, the Russian Federation in 2014–2015, Portugal in 2004–2006, Ukraine in 2013, Venezuela in 2014–2015, Canada in 2014–2015, Philippines in 2004–05 and 2012–2015, and Australia in 2005. In these cases, the ASMR for the three-year period was computed by using the available years

period, and the percentage changes in rates over the 2004–2015 period (whenever data were available) in 28 selected major countries. Data for the remaining countries are reported in eTable 1 and eTable 2 (online Supplement).

Mortality from suicide declined from the 2004–2006 to the 2013–2015 period in most countries considered. In men, the largest declines (over 20%) were observed in some Eastern European countries, where suicide rates were remarkably high in 2004–2006. Suicide rates declined by

39% in Russia, 34% in Kazakhstan, and 20–30% in Bulgaria, Estonia, Finland, Hungary, Latvia, Slovenia, Switzerland, and Ukraine. Among the non-European countries, the greatest downward trends were observed in Turkmenistan (– 80%), Venezuela (– 49%), and Panama (– 43%). However, suicide mortality increased remarkably in a few countries, such as Greece (+ 44%) and Guatemala (+ 38%). Unfavourable patterns were also registered in Mexico (+ 15%), the USA (+ 15%), the Netherlands

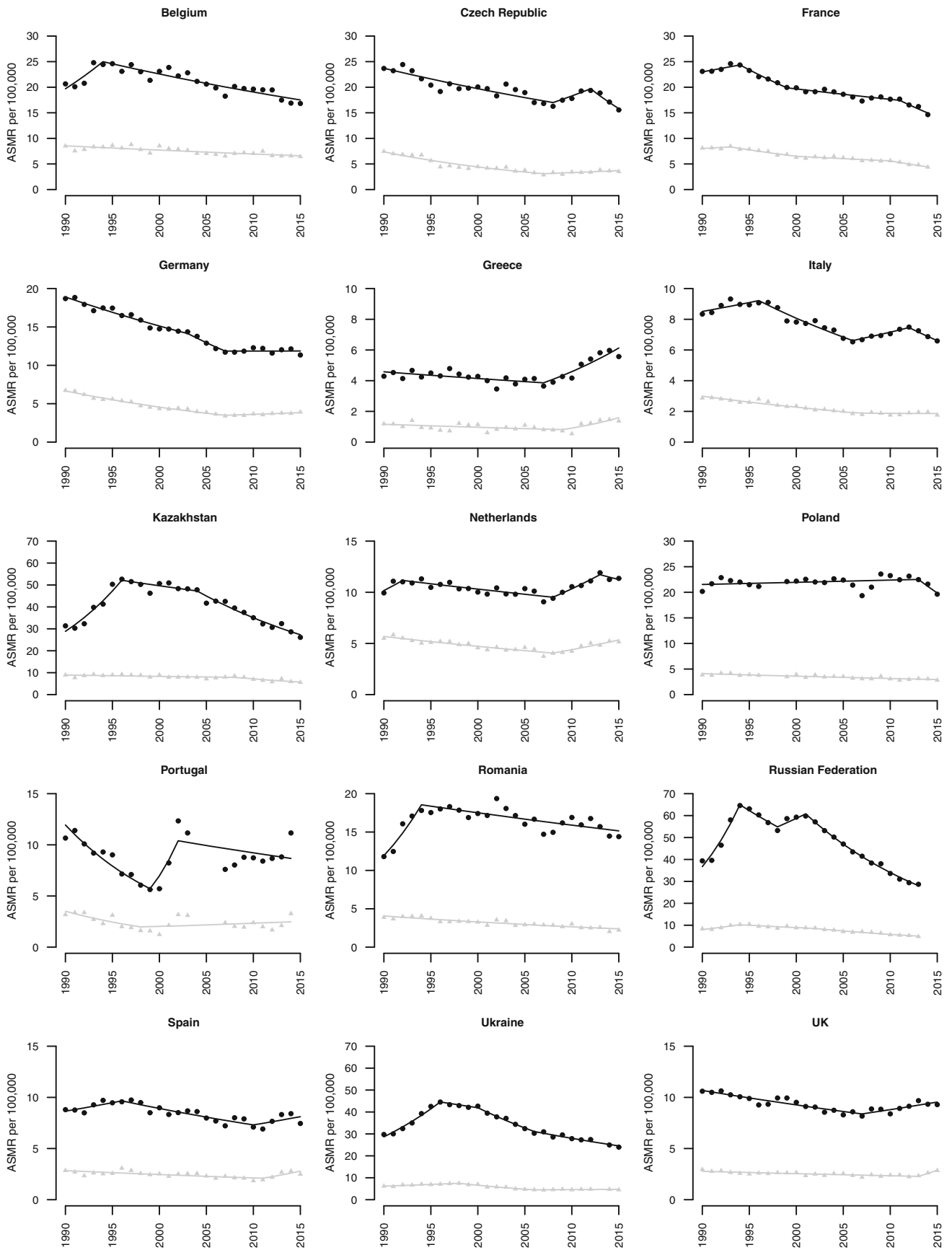
Table 2 Age-standardized (world population) mortality rates (ASMRs) from suicide (per 100,000) in women, average annual deaths of the latest period, and percentage changes, in 28 selected major countries worldwide by three-year calendar period (2004–2015)

	ASMRs				Average annual deaths (Latest period) 2013–15	Percentage changes		
	(Pre-crisis) 2004–06	(Around crisis) 2007–09	(Post-crisis) 2010–12	(Latest period) 2013–15		2013–15 vs. 2004–06	2007–09 vs. 2004–06	2010–12 vs. 2007–09
<i>Europe</i>								
Belgium	6.99	6.94	7.05	6.52	517	– 6.7	– 0.7	1.6
Czech Republic	3.55	3.06	3.39	3.66	276	3.1	– 13.8	10.8
France	6.24	5.64	5.28	4.61	2175	– 26.1	– 9.6	– 6.4
Germany	3.82	3.45	3.65	3.81	2546	– 0.3	– 9.7	5.8
Greece	0.97	0.78	0.98	1.42	110	46.4	– 19.6	25.6
Italy	1.97	1.87	1.82	1.89	872	– 4.1	– 5.1	– 2.7
Kazakhstan	7.56	8.15	6.46	6.22	589	– 17.7	7.8	– 20.7
The Netherlands	4.47	3.96	4.67	5.07	575	13.4	– 11.4	17.9
Poland	3.43	3.25	2.95	3.01	789	– 12.2	– 5.3	– 9.2
Portugal	.	2.12	2.02	2.69	249	.	.	– 4.7
Romania	2.92	2.80	2.68	2.27	342	– 22.3	– 4.1	– 4.3
Russian Federation	7.23	6.73	5.47	4.82	4985	– 33.3	– 6.9	– 18.7
Spain	2.32	2.17	1.99	2.66	915	14.7	– 6.5	– 8.3
Ukraine	4.72	4.59	4.67	4.61	1491	– 2.3	– 2.8	1.7
The UK	2.49	2.31	2.35	2.61	1055	4.8	– 7.2	1.7
<i>America</i>								
Argentina	2.77	2.65	2.57	2.66	608	– 4.0	– 4.3	– 3.0
Brazil	1.67	1.71	1.84	1.89	2222	13.2	2.4	7.6
Chile	3.08	4.25	3.68	3.29	334	6.8	38	– 13.4
Colombia	2.01	1.82	1.54	1.63	418	– 18.9	– 9.5	– 15.4
Cuba	4.72	4.03	3.98	3.62	301	– 23.3	– 14.6	– 1.2
Mexico	1.22	1.41	1.55	1.73	1160	41.8	15.6	9.9
Venezuela	1.36	1.09	0.87	0.74	116	– 45.6	– 19.9	– 20.2
Canada	4.38	4.45	4.59	4.77	1013	8.9	1.6	3.2
The USA	3.82	4.09	4.48	5.03	9632	31.7	7.1	9.5
<i>Australasia</i>								
Japan	8.90	9.37	9.17	7.94	7409	– 10.8	5.3	– 2.1
Philippines	0.94	0.99	1.09	.	524	.	5.3	10.1
Republic of Korea	11.60	14.93	14.28	11.40	4140	– 1.7	28.7	– 4.4
Australia	3.86	4.10	4.50	5.06	693	31.1	6.2	9.8

Note: Data were not available for France in 2015, the Russian Federation in 2014–2015, Portugal in 2004–2006, Ukraine in 2013, Venezuela in 2014–2015, Canada in 2014–2015, Philippines in 2004–05 and 2012–2015, and Australia in 2005. In these cases, the ASMR for the three-year period was computed by using the available years

(+ 14%), Uruguay (+ 12%), Australia (+ 11%), the UK (+ 10%), Brazil (+ 9.5%), and Macedonia (+ 9.3%). Women showed sizably lower suicide rates than men, with similar trends for most countries. Opposite trends were observed for the Czech Republic, Spain, Canada, Chile,

Fig. 1 Joinpoint analysis of age-standardized mortality rates (ASMRs) per 100,000 person-years from suicides over the period 1990–2015 (whenever available) by selected major European countries by sex. Symbols indicate the observed ASMRs (dots in men and triangles in women). Black and grey lines indicate the estimated ASMRs in men and women, respectively



Puerto Rico, and New Zealand, where rates increased in women, while they declined in men.

eFigure 1 in the online Supplement shows suicide mortality rates in the most recent period (2013–2015) ranked from the highest to the lowest. In men, most Eastern European countries, the Republic of Korea, Uruguay, and Japan showed the highest rates. In women, Korea showed the highest rate, followed by Japan and Lithuania. In both sexes, Latin American countries, Italy, Greece, Israel, Turkmenistan, and Kuwait had very low mortality rates. Suicide rates were higher in men than in women with sex ratios ranging between three and five in most countries. Eastern Europe showed the highest sex ratios with values up to seven (eFig. 2 in the online Supplement).

eTable 3 shows the percentages of deaths coded to ill-defined and external causes of undetermined intent in the 58 selected countries (maximum value over the 2004–2015 period). The percentage of ill-defined deaths ranged between 2.2 and 31.3% with very high values (> 20%) in Poland, Bulgaria, Guatemala, Greece, Argentina, and Kazakhstan. The percentage of deaths with undetermined intent was below 0.5% in most countries, with higher values in Guatemala (7.2%), Venezuela (6.4%), Slovakia (5.7%), Kazakhstan (1.7%), and Kuwait (1.5%). These two measures indicate potential issues with the quality of death certification and under-reporting of suicide deaths in those countries.

Figures 1, 2, and Table 3 show the results of the joinpoint analysis for suicide trends at all ages in 28 selected larger countries worldwide from 1990 to 2015 (when available).

Over the studied period, most countries showed downward trends starting from the beginning of 1990s in Belgium (in women), the Czech Republic (in men), Kazakhstan (in women), Poland (in women), and Romania (in women); from the mid-1990s in Belgium (in men), France, Romania (in men), the Russian Federation (in women), and Ukraine; from the 2000s in the Russian Federation (in men), Argentina, Colombia (in men), and Venezuela; and more recently in Chile, Japan, and the Republic of Korea (in women).

Suicide rates steadily declined until mid-2000s and then tended to level off or slightly rise over the most recent years in the Czech Republic (in women), Germany, Italy, Spain, Canada, and Cuba. Poland showed a stable mortality trend in men and a slight fall in women over the whole period.

Substantial rises were observed in Greece (APC = + 6 since 2007 in men and + 11.8 since 2009 in women), the Netherlands (APC = + 4.2 in 2008–2013 in men and + 4.0 since 2008 in women), the UK (APC = + 1.6 since 2007 in men and + 12.4 since 2013 in women, although the estimate in women was based only on 3 years), Brazil

Fig. 2 Joinpoint analysis of age-standardized mortality rates per 100,000 person-years from suicides over the period 1990–2015 (whenever available) by selected major non-European countries by sex. Symbols indicate the observed ASMRs (dots in men and triangles in women). Black and grey lines indicate the estimated ASMRs in men and women, respectively

(APC = + 0.8 since 1990 in men and + 1.8 since 1999 in women), Mexico (APC = + 1.3 since 1995 in men and + 3.6 since 1990 in women), the USA (APC = + 1.7 since 2005 in men and + 4.2 since 2010 in women), Philippines (APC = + 4.8 in men and + 2.4 in women, since 1992 in both sexes), and Australia (APC = + 1.8 in men and + 3.7 in women, since 2006 in both sexes).

Different mortality trends emerged across age groups for some of the selected 28 countries in men (eFigure 3, eFigure 4 in the online Supplement) and in women (eFigs. 5 and 6 in the online Supplement). In Belgium, the Czech Republic, France, Germany, Italy, and Spain mortality trends dropped considerably in the elderly (over 65 years old), while they were stable or declined slightly in the young (15–24 years) and the middle aged (25–64 years). For countries showing unfavourable trends, the increase involved all the age groups in Greece, Brazil, US women, Philippines, and Australia, the young and middle-aged groups in Mexico, the middle- and older-aged groups in the Netherlands, and the middle-aged men in the USA. In Argentina, suicides decreased in the elderly, while they increased in the young. In Japan, the mortality rate in middle- and older-aged men decreased remarkably since the 2000s, while it increased in the young. In Japanese women, the rate declined since the 1990s mostly among older individuals. In the Republic of Korea, the mortality rates increased sharply in older people until the 2010s, and dropped thereafter.

Discussion

Main findings

Over the 2000s, mortality from suicide declined in most countries, with some exceptions showing upward trends, including Greece, the Netherlands, the UK, Brazil, Mexico, the USA, Philippines, and Australia. The Russian Federation, other Eastern European countries, and Japan showed decreasing trends, but they still rank among the countries with the highest suicide mortality rates. Since 2010, the Republic of Korea displayed a remarkable downward trend in men aged 65 and over, and in women at all ages, while maintaining very high rates in both sexes.

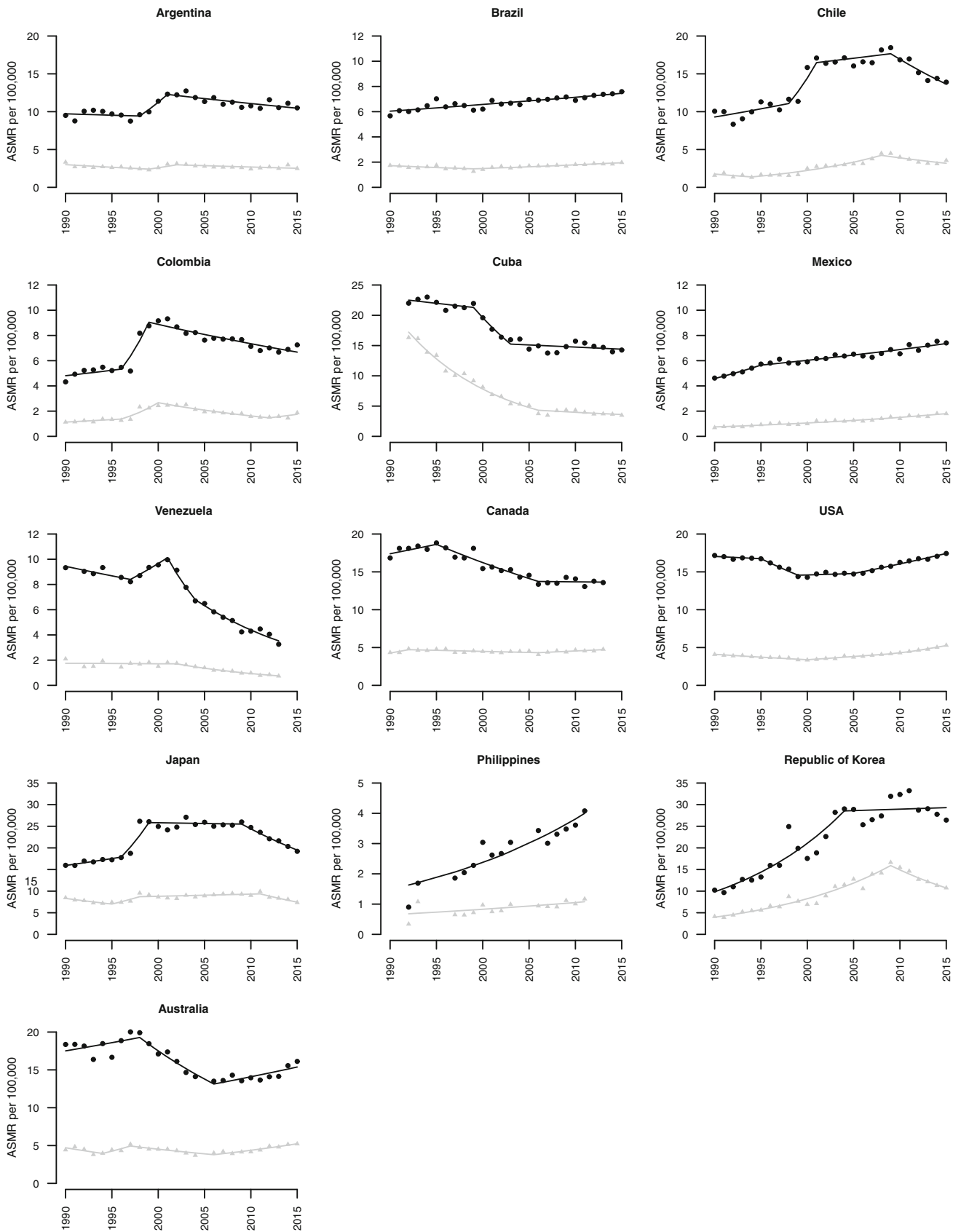


Table 3 Joinpoint analysis for suicides in men and women at all ages, in selected countries, from 1990 to 2015 (according to data availability)

	Men								Women							
	Period 1	APC 1	Period 2	APC 2	Period 3	APC 3	Period 4	APC 4	Period 1	APC 1	Period 2	APC 2	Period 3	APC 3	Period 4	APC 4
<i>Europe</i>																
Belgium	1990–1994	6.1 ^a	1994–2015	- 1.7 ^a					1990–2015	- 1 ^a						
Czech Republic	1990–2008	- 1.8 ^a	2008–2012	3.7	2012–2015	- 7.1			1990–2007	- 5 ^a	2007–2015	2.3				
France	1990–1994	1.5	1994–1999	- 4 ^a	1999–2011	- 1.1 ^a	2011–2014	- 5 ^a	1990–1993	1.3	1993–2000	- 3.5 ^a	2000–2010	- 1.5 ^a	2010–2014	- 5.7 ^a
Germany	1990–2003	- 2.2 ^a	2003–2007	- 4.3 ^a	2007–2015	0			1990–2007	- 3.7 ^a	2007–2015	1.2 ^a				
Greece	1990–2007	- 1 ^a	2007–2015	6 ^a					1990–2009	- 1.8 ^a	2009–2015	11.8 ^a				
Italy	1990–1996	1.3	1996–2006	- 3.3 ^a	2006–2012	2	2012–2015	- 3.9	1990–2007	- 2.7 ^a	2007–2015	- 0.1				
Kazakhstan	1990–1996	10.4 ^a	1996–2004	- 1.2	2004–2015	- 4.9 ^a			1990–2008	- 0.7 ^a	2008–2015	- 4.5 ^a				
The Netherlands	1990–1992	4.8	1992–2008	- 1 ^a	2008–2013	4.2 ^a	2013–2015	- 2	1990–2008	- 1.9 ^a	2008–2015	4 ^a				
Poland	1990–2013	0.2	2013–2015	- 6.1					1990–2015	- 1.3 ^a						
Portugal	1990–1999	- 7.9 ^a	1999–2002	22.1	2002–2014	- 1.5			1990–1998	- 6.9	1998–2014	1.4				
Romania	1990–1994	11.7 ^a	1994–2015	- 1 ^a					1990–2015	- 2.1 ^a						
Russian Federation	1990–1994	15.3 ^a	1994–1998	- 4.1	1998–2001	3.5	2001–2013	- 6.2 ^a	1990–1994	6.2 ^a	1994–2002	- 2.3 ^a	2002–2013	- 4.7 ^a		
Spain	1990–1996	1.9	1996–2010	- 2 ^a	2010–2015	2.1			1990–2011	- 1.4 ^a	2011–2015	7.4				
Ukraine	1990–1996	7.6 ^a	1996–2000	- 1.5	2000–2006	- 4.9 ^a	2006–2015	- 2.6 ^a	1990–1998	2.4 ^a	1998–2006	- 6.1 ^a	2006–2015	0.5		
The UK	1990–2007	- 1.4 ^a	2007–2015	1.6 ^a					1990–2013	- 0.9 ^a	2013–2015	12.4 ^a				
<i>The Americas</i>																
Argentina	1990–1998	- 0.4	1998–2001	9.2	2001–2015	- 1.1 ^a			1990–1999	- 2.4 ^a	1999–2002	7.4	2002–2015	- 1.3 ^a		
Brazil	1990–2015	0.8 ^a							1990–1999	- 1.7 ^a	1999–2015	1.8 ^a				
Chile	1990–1998	2.2	1998–2001	14.1	2001–2009	0.9	2009–2015	- 4.2 ^a	1990–1994	- 5.8	1994–2008	8.3 ^a	2008–2015	- 4 ^a		
Colombia	1990–1996	1.8	1996–1999	19.3 ^a	1999–2015	- 1.9 ^a			1990–1996	3.2	1996–2000	18.1 ^a	2000–2012	- 4.8 ^a	2012–2015	6.1
Cuba	1992–1999	- 0.8	1999–2003	- 8 ^a	2003–2015	- 0.5			1992–2006	- 9.4 ^a	2006–2015	- 2				
Mexico	1990–1995	4.3 ^a	1995–2015	1.3 ^a					1990–2015	3.6 ^a						
Venezuela	1990–1997	- 1.7	1997–2001	4.8	2001–2004	- 12.4	2004–2013	- 7 ^a	1990–2002	- 0.2	2002–2013	- 7.2 ^a				
Canada	1990–1995	1.4	1995–2006	- 2.7 ^a	2006–2013	- 0.1			1990–1992	5.2	1992–2006	- 0.6 ^a	2006–2013	1.3 ^a		
The USA	1990–1995	- 0.4	1995–1999	- 3.4 ^a	1999–2005	0.3	2005–2015	1.7 ^a	1990–2000	- 1.9 ^a	2000–2010	2.3 ^a	2010–2015	4.2 ^a		
<i>Australasia</i>																
Japan	1990–1996	1.9 ^a	1996–1999	13.1 ^a	1999–2009	- 0.1	2009–2015	- 4.4 ^a	1990–1995	- 3.4 ^a	1995–1998	7.5	1998–2011	0.6	2011–2015	- 5.5 ^a
Philippines	1992–2011	4.8 ^a							1992–2011	2.4 ^a						
Republic of Korea	1990–2004	7.9 ^a	2004–2015	0.2					1990–2009	7.6 ^a	2009–2015	- 6.4 ^a				
Australia	1990–1998	1.2	1998–2006	- 4.7 ^a	2006–2015	1.8 ^a			1990–1994	- 4.3	1994–1997	7.6	1997–2006	- 2.9 ^a	2006–2015	3.7 ^a

APC annual percentage change

^aSignificantly different from zero ($P < 0.05$)

Interpretation of findings

The declines in suicide mortality observed over the 2000s in most countries follow widespread favourable trends registered since the 1980s, attributed to better management of psychiatric disorders (Levi et al. 2003).

On the other hand, our findings confirm, and extended to more recent calendar years, the results of previous studies that reported excess suicide deaths in concomitance to the financial crisis in Greece, the Netherlands, and the UK (Stuckler et al. 2011; Chang et al. 2013; Reeves et al. 2014; Harper et al. 2015; Laanani et al. 2015; Nordt et al. 2015; Economou et al. 2016).

During the period covered by our study, important socio-economic and political changes may have increased the prevalence of the main risk factors for suicides, including mental conditions (Katikireddi et al. 2012; Roca et al. 2013; Economou et al. 2016). Between 2008 and 2015, in Greece, the Netherlands, Italy, and Spain, the unemployment rate rose remarkably, and this was associated with a corresponding surge in the suicide mortality rate in Greece and the Netherlands, and with a levelling of the pre-crisis downward trend in Italy and Spain (eFigure 7 and eFigure 8 in the online Supplement).

So far, studies aiming to quantify these effects used two different approaches. Some have estimated the effect of the worsening of selected economic indicators, mainly the unemployment rate, on suicide mortality (Harper et al. 2015; Laanani et al. 2015; Nordt et al. 2015), while others compared the mortality rate before and after the crisis to obtain a “whole crisis effect” that embraces other factors besides economic determinants (Barr et al. 2012; Chang et al. 2013; Reeves et al. 2014). Still, the pattern of trends differed appreciably across countries likely due to the different labour market and social support policies that may have mitigated the negative effects of the financial crisis. Moreover, the effects of rising unemployment are stronger in countries with lower pre-crisis unemployment rates (Nordt et al. 2015). Thus, other contextual factors likely played a relevant role. We found increases in mortality rates from suicide following the 2008 financial crisis in Greece, the UK, and the Netherlands that agrees with a “crisis effect.” In Germany, Italy, and Spain, the pre-crisis downward trend stopped, indicating a negative effect of the financial downturn in these countries too. However, the results for the USA did not support a crisis effect since the upward trend started in 2000, well before the crisis onset. The reasons of this increment have not been clarified, but the opioid epidemic among the non-Hispanic White population could have at least partly contributed to the upward trend in the US middle-aged population. However, other factors are likely to be involved, including the collapse of

some local rural economies and increased distress among the middle-aged “working class Whites” who experienced hopelessness and disillusion as they entered the labour market with poor prospects, low-paid job, and less opportunities than the previous generation (Stein et al. 2017; Woolf and Aron 2018).

There is growing concern about the rise in suicide mortality in low- and middle-income countries that may result from inadequate detection and treatment of psychiatric disorders (Chisholm et al. 2007; Borges et al. 2010). The reasons for the increase in suicide mortality in Brazil and Mexico have not been established, although they should be sought in a combination of socio-economic, psychological, and cultural factors (Borges et al. 2010; Bando et al. 2012). Some subsets of the population, such as those living in rural areas with limited access to health care services, could be at higher risk. Moreover, these countries had low absolute rates, which may indicate some degree of under-ascertainment and under-registration.

Social instability induced by the USSR breakup in the early 1990s induced socio-economic changes in the former Soviet Republics that considerably affected suicide mortality (Jukkala et al. 2017). These changes had a greater effect on older cohorts who experienced greater adaptation problems to the modernization process following these events. Moreover, alcohol abuse is among the reasons explaining the very high suicide rates in these countries. However, the 2006 alcohol regulation decreased spirits consumption by 33% in the Russian Federation, and this was mirrored by a downturn in premature mortality from external causes, including suicides (Pridemore et al. 2013; Zaridze et al. 2014).

Likewise, the Asian financial crisis induced a steep increase in suicide rates in Japan and South Korea in the late 1990s (Jeon et al. 2016). To cope with that dramatic public health problem, in 2006, Japan promoted a national strategy that involved enhancement of psychiatric treatment services and supportive observation by family members. Those measures likely contributed to the decreasing trend observed thereafter. In South Korea, the major recession in the mid-1990s and maladaptation to the fast industrialization process may have contributed to the surge in suicide mortality over the 1990s and the early 2000s (Jeon et al. 2016). The dramatic societal changes that occurred during that period favoured psychological problems and social isolation with more deleterious effects among the elderly with longer life expectancy, growing health issues, and poor social support (Jeon et al. 2016).

Some individuals are more sensitive to socio-economic changes in periods of economic crisis and stagnation, such as people of working age and those with less education in the USA (Harper et al. 2015), low-level workers in Greece

(Alexopoulos et al. 2016), and managers and professional workers in Japan (Wada et al. 2012).

Over the period considered in the present study, suicide mortality rates were higher in the older population compared to the young, although they are approaching those of middle-aged individuals in most countries. In contrast, in the UK, Australia, and Canada mortality rates were higher in midlife than at older ages. These age-specific patterns have important implications from a public health perspective, since they give insights into different mechanisms underlying the suicide mortality trends in each country, with economic instability affecting the working population more (Breuer 2015), while social exclusion and chronic diseases have a predominant role among the elderly population (Yur'yev et al. 2010).

Strengths and limitations

This study provides a comprehensive global picture with the most updated data on suicide mortality for several countries covering a period of great socio-economic turmoil that followed the 2008 global financial crisis.

It should be considered that suicide suffers from under-reporting due to uncertain determination of intent and, also to legal, religious, and political pressures. Therefore, the uncertain validity of death certification for suicide in some countries is a major limitation of this study. There is a high degree of between-country heterogeneity in the quality of death certification, and some countries may have under-reported suicides with a share of violent deaths usually classified as undetermined intent or accident. In fact, some Latin American countries, Slovakia, Kazakhstan, Kuwait, Republic of Korea, Portugal, Lithuania, Estonia, and Philippines certified more than 1% of deaths as undetermined intent. Interestingly, Venezuela, despite being one of the countries most affected by the financial crisis, reported a decreasing trend in suicide rate, which could be at least partly due to under-reporting. On the other hand, other countries may have inflated the reporting after the financial crisis due to media pressure.

In addition, there are between-country differences in the methods used to attempt suicide and the fatality ratio strictly depends on the method used to attempt suicide, with higher lethality for self-injury by firearm and hanging/suffocation, and very low fatal ratio for self-injury by sharp instrument and poisoning. All these limitations mainly affect between-country comparisons, while the validity of trend analysis is considered reliable.

Finally, our study only covered about one-fourth of the global population with larger proportion of high- and middle-income countries and did not include two of the most populous countries, i.e. China and India.

Conclusions and implications

In conclusion, mortality from suicide declined in most countries, but some countries showed upward trends around the 2008 global financial crisis, while others interrupted their pre-crisis downward trends. This calls for public interventions to improve mental health and social services, as well as labour market protection and policies to promote social inclusion.

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Authors' Contribution CLV conceived and PB designed the study. PB and GA performed the data analysis and drafted the manuscript. All authors participated equally in the interpretation of the results. PB has full responsibility for the overall content of the manuscript.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest.

Data availability All data used in this manuscript are publicly available in the WHO mortality database. Geneva: World Health Organization, 2014 (http://www.who.int/healthinfo/statistics/mortality_rawdata/en/index.html) and Pan American Health Organization (PAHO), Health Information Platform for the Americas (<http://www.paho.org/data/index.php/en/indicators/demographics-core/308-poblacion-nac-en.html>).

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