Declining Amenable Mortality: Time Trend (2000–2013) and Geographic Area Analysis

Maria Michela Gianino, Jacopo Lenzi, Aida Muça, Maria Pia Fantini, Roberta Siliquini, Walter Ricciardi, and Gianfranco Damiani

Objective. To update amenable mortality in 32 OECD countries at 2013 (or last available year), to describe the time trends during 2000–2013, and to evaluate the association of these trends with various geographic areas.

Data Sources. Secondary data from 32 countries during 2000–2013, gathered from the World Health Organization Mortality Database.

Study Design. Time trend analysis.

Data Collection. Using Nolte and McKee's list, age-standardized amenable mortality rates (SDRs) were calculated as the annual number of deaths over the population aged 0–74 years per 100,000 inhabitants. We performed a mixed-effects polynomial regression analysis on the annual SDRs to determine whether specific geographic areas were associated with different SDR trajectories over time.

Principal Findings. The OECD average annual decrease was 3.6/100,000 ($p < .001$), but slowed over time (coefficient for the quadratic term = 0.11, $p < .001$). Eastern and Atlantic European countries had the steepest decline (−6.1 and −4.7, respectively), while Latin American countries had the lowest slope (−1.7). The OECD average annual decline during the 14-year period was −0.5 ($p < .001$) for cancers and −2.5 ($p < .001$) for cardiovascular diseases, with significant differences among countries.

Conclusion. Declining trend of amenable SDRs was continuing to 2013 but with steepness change compared with previous periods and with a slowdown.

Key Words. Amenable mortality, health care services performance, geographic area, OECD countries

Amenable mortality is defined as deaths that could theoretically be prevented by timely access to good quality health care (Lavergne and McGrail 2013). The basic idea is that health care may prevent mortality from a number of causes by means of preventive or therapeutic measures (Nolte and McKee

2008). This concept was originally developed by Rustein et al. (1976), who created a list of conditions that were considered either treatable or preventable given the current medical knowledge and technology, and subsequently it was explored in several European countries (Charlton and Velez 1986; Poikolainen and Eskola 1986; Holland 1988; Mackenbach 1996).

This concept has been revitalized recently as a potential indicator of the impact of health system performance on population health (Nolte and McKee 2004, 2008; Page, Tobias, and Glover 2006; National Health Service [NHS] 2010; Gay et al. 2011).

Several studies have used amenable mortality to assess socioeconomic equality in the outcome of health care. These studies showed that standardized mortality rates are lower in populations with high education levels (Stirbu et al. 2010), that mortality from amenable causes is higher for people in a lower social class (Poikolainen and Eskola 1995; Tobias and Jackson 2001), and that there is little evidence of inequity between immigrants and native populations (Westerling and Rosén 2002; Stirbu et al. 2006).

Other studies have compared various countries, or states within countries, using amenable mortality. The Commonwealth Fund in the United States used amenable mortality to compare the performance of health systems across the 50 states (Commonwealth Fund 2011). Nolte and McKee (2011) used amenable mortality to compare performance across 16 high-income nations. By 2006/2007, the combined levels of amenable mortality were lowest in France at 55 deaths per 100,000 persons, followed by Australia (59.92) and Italy (59.88). The highest levels were observed in the United States, with 95.54 deaths per 100,000, followed by the United Kingdom (82.54) and Denmark (80.13) (Nolte and McKee 2011).

Previous studies have also evaluated amenable mortality trends over time. Nolte and McKee (2008) conducted a study of amenable mortality in 19 OECD countries between 1997/1998 and 2002/2003, and in 2012 (Nolte and McKee 2012), they examined trends of amenable mortality in the United

Address correspondence to Maria Michela Gianino, M.S., Department of Public Health Sciences and Pediatrics, Università di Torino, Via Santena 5/bis, 10126 Torino, Italy; e-mail: mariola.gianino@unito.it. Jacopo Lenzi, Ph.D. and Maria Pia Fantini, M.D., are with the Department of Biomedical and Neuromotor Sciences, Alma Mater Studiorum – Università di Bologna, Bologna, Italy. Aida Muça, M.D., is with the Department of Public Health Sciences and Pediatrics, Università di Torino, Torino, Italy. Roberta Siliquini, M.D., is with the Department of Public Health Sciences and Pediatrics, Università di Bologna, Bologna, Italy. Walter Ricciardi, M.D., and Gianfranco Damiani, M.D., are with the Department of Public Health, Università Cattolica del Sacro Cuore, Rome, Italy.

States, France, Germany, and the United Kingdom between 1999 and 2007. Gay et al. (2011) compared amenable mortality rates in 31 OECD countries from 1997 to 2007 and found a declining trend in amenable mortality rates in every examined time period.

The aim of our study was to update the amenable mortality rates in 32 OECD countries at 2013 or the last available year, to describe the annual variations in mortality amenable to health care during 2000–2013, to determine whether these changes were constant over time, and to evaluate the pattern across geographic areas.

METHODS

A time trend analysis was performed using secondary data from 32 OECD countries during the period 2000 to 2013. These countries were chosen based on the availability of data and to allow for comparison with the study by Gay et al. (2011).

The mortality and population data for this study came primarily from the *World Health Organization (WHO) Mortality Database* (World Health Organization [WHO] 2014), in which causes of death are coded according to the ICD-9 or ICD-10. If reference populations were not available in the WHO Mortality Database, the data were extracted from the *2012 Revision of the World Population Prospects* (United Nations [UN] 2014). The countries included in the study are listed in Appendix S1.

Nolte and McKee (2003, 2004, 2008) and Tobias and Yeh (2009) prepared two different lists of causes of death amenable to health care. These two lists were used by the OECD to generate estimates of amenable mortality for 31 countries (Gay et al. 2011). After reviewing the two sets of estimates of amenable mortality for the OECD countries provided by Nolte and McKee's and Tobias and Yeh's lists, we decided to use Nolte and McKee's because it provides, on average, more conservative figures. Nolte and McKee's list of causes of death amenable to health care is in Appendix S2.

For each country, age-standardized amenable mortality rates (amenable SDRs) were calculated as the annual number of deaths in the population aged 0–74 years per 100,000 inhabitants, with direct standardization to the 2010 OECD population. SDRs were stratified by geographic area (Northern Europe, Central Europe, Atlantic Europe, Southern Europe, Eastern Europe, North America, Latin America, Middle East, East Asia, and Oceania) (Rossi et al. 2015; World Bank 2015) and three disease categories—the two leading

causes of death amenable to health care in OECD countries during the examined years (cancers and cardiovascular diseases) and all of the remaining causes (see Appendix S2).

First, the data were summarized by presenting the average annual amenable SDRs for the years 2000/2003 and 2010/2013 and by computing the percentage change in amenable SDRs between these time periods. Second, we performed a mixed-effects polynomial regression analysis on the annual amenable SDRs, with random intercepts and slopes for each country. In this model, we included geographic area and its interaction with year to determine whether specific geographic areas were associated with different amenable SDR trajectories over time. We chose to fit a polynomial model to investigate the presence of nonlinear trajectories of amenable SDRs, that is, to determine whether the annual changes in amenable SDRs were constant over time. Finally, we estimated confidence intervals for all linear and quadratic slope parameters to test whether they were *smaller*, *larger*, or *indistinguishable* (i.e., *neither smaller nor larger*) compared with the average value across all OECD countries.

For all analyses, the significance level was set at $p < .05$. All data were analyzed using the *Stata software package, version 13* (StataCorp. 2013, Stata Statistical Software: Release 13; StataCorp LP, College Station, TX, USA).

RESULTS

Amenable SDRs

Figure 1 displays the amenable SDRs from all causes per 100,000 persons aged 0–74, in all 32 countries, stratified by geographic area. All countries experienced decreases in amenable mortality between 2000 and 2013, with differences among geographic regions. Countries in Atlantic Europe, North America, and Oceania showed homogeneous declines, whereas Latin America, East Asia, and Eastern Europe exhibited large within-region differences in the reduction of amenable mortality. Diseases of the cardiovascular system and cancers were the two leading causes of amenable mortality and accounted for 48.4 and 25.8 percent, respectively, of overall amenable mortality in OECD countries during the 14-year period.

Table 1 shows amenable SDRs from all causes, as well as cancers, cardiovascular diseases, and other causes, for the years 2000/2003 and 2010/2013. Between 2000/2003 and 2010/2013, mortality from all amenable causes decreased by more than 30 percent in Northern Europe, Atlantic Europe, and Oceania (–31.3, –34.2, and –30.2 percent, respectively) and by 8.6 percent

Figure 1: Amenable Age-Standardized Death Rates from All Causes (Per 100,000) for Ages 0–74 in 32 OECD Countries Stratified by Geographic Region (2000–2013, or Last Available Year)

Note. Missing data within the time-series of Italy (2004, 2005), Portugal (2004–2006), and Australia (2005) were interpolated by connecting the lines between the nonmissing data points. AUS, Australia; AUT, Austria; BEL, Belgium; CAN, Canada; CHL, Chile; CZE, Czech Republic; DEU, Germany; DNK, Denmark; ESP, Spain; EST, Estonia; FIN, Finland; FRA, France; GBR, United Kingdom; GRC, Greece; HUN, Hungary; IRL, Ireland; ISL, Iceland; ISR, Israel; ITA, Italy; JPN, Japan; KOR, South Korea; LUX, Luxembourg; MEX, Mexico; NDL, Netherlands; NOR, Norway; NZL, New Zealand; POL, Poland; PRT, Portugal; SVK, Slovakia; SVN, Slovenia; SWE, Sweden; USA, United States of America.

Table 1: Amenable Age-Standardized Death Rates (Per 100,000) for Ages 0–74 from All Causes, Cancers, Cardiovascular Diseases, and Other Conditions in 32 OECD Countries, 2000/2003 and 2010/2013 (or Last Available Years)

Geographic Area and Country	Amenable SDR ₀₋₇₄ 2000/2003 ^{a,†}				Amenable SDR ₀₋₇₄ 2010/2013 ^{a,‡}				% Change 2010/2013–2000/2003			
	All Causes	Tumors	CV Diseases	Other Causes	All Causes	Tumors	CV Diseases	Other Causes	All Causes	Tumors	CV Diseases	Other Causes
Northern Europe	96	28	52	16	66	22	31	12	–31.3	–21.4	–40.4	–25.0
Denmark	109	37	52	20	72	28	28	15	–33.9	–24.3	–46.2	–25.0
Finland	106	22	65	19	71	19	43	10	–33.0	–13.6	–33.8	–47.4
Iceland	78	24	43	11	n/a	n/a	n/a	n/a	n/a	n/a	n/a	n/a
Norway	90	30	46	14	59	23	25	11	–34.4	–23.3	–45.7	–21.4
Sweden	85	24	48	13	60	21	28	11	–29.4	–12.5	–41.7	–15.4
Central Europe	91	20	44	17	66	24	28	15	–27.5	–17.2	–36.4	–11.8
Austria	97	29	53	15	64	21	33	10	–34.0	–27.6	–37.7	–33.3
Belgium	92	29	42	21	66	24	26	16	–28.3	–17.2	–38.1	–23.8
France	72	27	29	15	54	23	19	12	–25.0	–14.8	–34.5	–20.0
Germany	102	30	53	18	72	24	32	16	–29.4	–20.0	–39.6	–11.1
Luxembourg	92	26	50	16	61	22	25	15	–33.7	–15.4	–50.0	–6.3
Netherlands	93	31	44	18	62	27	22	13	–33.3	–12.9	–50.0	–27.8
Atlantic Europe	114	29	62	23	75	24	34	17	–34.2	–17.2	–45.2	–26.1
Ireland	122	35	61	26	74	28	34	13	–39.3	–20.0	–44.3	–50.0
United Kingdom	114	29	62	23	74	23	34	17	–35.1	–20.7	–45.2	–26.1
Southern Europe	86	26	45	15	63	23	28	12	–26.7	–11.5	–37.8	–20.0
Greece	96	20	62	14	74	20	43	12	–22.9	0.0	–30.6	–14.3
Italy	81	26	42	13	62	23	28	11	–23.5	–11.5	–33.3	–15.4
Portugal	121	29	65	26	78	26	33	18	–35.5	–10.3	–49.2	–30.8
Spain	82	26	39	17	59	23	24	11	–28.0	–11.5	–38.5	–35.3
Eastern Europe	180	39	112	29	136	33	77	25	–24.4	–15.4	–31.3	–13.8
Czech Republic	167	43	99	24	114	30	63	20	–31.7	–30.2	–36.4	–16.7

Continued

Table 1. Continued

Geographic Area and Country	Amenable SDR ₀₋₇₄ 2000/2003 ^{*,†}				Amenable SDR ₀₋₇₄ 2010/2013 ^{*,‡}				% Change 2010/2013–2000/2003			
	All Causes	Tumors	Diseases	Other Causes	All Causes	Tumors	Diseases	Other Causes	All Causes	Tumors	Diseases	Other Causes
Estonia	260	35	180	45	156	30	106	21	-40.0	-14.3	-41.1	-53.3
Hungary	228	50	151	27	170	43	107	20	-25.4	-14.0	-29.1	-25.9
Poland	164	34	101	30	120	31	62	27	-26.8	-8.8	-38.6	-10.0
Slovakia	221	42	142	37	170	35	101	35	-23.1	-16.7	-28.9	-5.4
Slovenia	125	34	68	23	86	30	42	14	-31.2	-11.8	-38.2	-39.1
North America	115	27	61	27	91	22	45	25	-20.9	-18.5	-26.2	-7.4
Canada	84	27	41	16	66	22	28	15	-21.4	-18.5	-31.7	-6.3
United States of America	119	27	64	29	94	22	47	26	-21.0	-18.5	-26.6	-10.3
Latin America	139	20	64	54	127	18	59	50	-8.6	-10.0	-7.8	-7.4
Chile	125	22	68	34	101	21	52	28	-19.2	-4.5	-23.5	-17.6
Mexico	140	20	64	57	132	18	61	53	-5.7	-10.0	-4.7	-7.0
Middle East												
Israel	97	30	41	26	68	24	23	21	-29.9	-20.0	-43.9	-19.2
East Asia	87	21	44	23	63	19	27	17	-27.6	-9.5	-38.6	-26.1
Japan	79	22	37	21	63	21	26	17	-20.3	-4.5	-29.7	-19.0
South Korea	122	17	79	27	64	16	30	18	-47.5	-5.9	-62.0	-33.3
Oceania	86	30	42	14	60	22	26	12	-30.2	-26.7	-38.1	-14.3
Australia	82	29	40	14	57	21	24	12	-30.5	-27.6	-40.0	-14.3
New Zealand	105	37	55	13	74	28	35	11	-29.5	-24.3	-36.4	-15.4

*Iceland excluded from amenable SDR 2000/2003 and 2010/2013 of Northern Europe.

†Amenable SDR 2001/2003 (data not available for 2000) for United Kingdom; Atlantic Europe.

‡Amenable SDR 2010/2012 (data not available for 2013) for Denmark, Belgium, Ireland, Greece, Italy, Estonia; Northern Europe, Atlantic Europe, Southern Europe.

Amenable SDR 2010/2011 (data not available for 2012/2013) for France, Australia, New Zealand; Central Europe, Oceania. Amenable SDR 2010 (data not available for 2011/2013) for Slovakia, Slovenia, Canada, USA, Chile, Mexico; Eastern Europe, North America, Latin America.
CV, cardiovascular; n/a, not available; SDR, age-standardized death rate.

in Latin America. The percentage change was approximately 20–30 percent in all of the other regions. The lowest percentage change was found in Mexico (−5.7 percent), whereas the highest change occurred in South Korea (−47.5 percent). Additionally, the percentage decrease in the cardiovascular disease SDR was higher than the percentage change in the all-cause SDR in all countries. In contrast, the percentage change in the SDR from cancer was always lower than the corresponding change in the all-cause SDR, with the sole exception of Mexico.

Annual Trends in Amenable SDRs

OECD Countries. The OECD average annual decrease in amenable mortality was 3.6 per 100,000 (coefficient for the linear term = −3.6; 95 percent CI = −4.2, −2.9), but this decrease slowed over time (coefficient for the quadratic term = 0.11; 95 percent CI = 0.08, 0.14) (Figure 2). The mixed-effects regression model showed that there was a significant difference among the country-specific slopes (standard deviation [SD] = 1.8, $p < .001$). Countries

Figure 2: Estimated Annual Change in Amenable Age-Standardized Death Rates (Per 100,000) from All Causes, Overall, and Stratified by Geographic Region (2000–2013) [Color figure can be viewed at [wileyonlinelibrary.com](#)]

with slopes steeper than the OECD average had high amenable SDR values in 2000. Specifically, Estonia, Hungary, Slovakia, Czech Republic, Poland, Ireland, Slovenia, South Korea, and Portugal had amenable mortality above 125 per 100,000 inhabitants (277, 246, 231, 176, 175, 138, 132, 130, and 127, respectively) in 2000. Countries with slopes less steep than the OECD average had different patterns: Canada, Australia, Italy, Spain, Japan, Iceland, and France had amenable mortality under 90 per 100,000 inhabitants (89, 88, 86, 85, 83, 82, and 75, respectively) in 2000, whereas Mexico, Chile, the United States, and Germany had a relatively high amenable mortality in 2000 (144, 130, 123, and 106, respectively).

All OECD countries experienced a slowdown in the reduction of amenable SDRs during the 14-year period, with the exception of Denmark (coefficient for the quadratic term = 0.00; 95 percent CI = -0.07, 0.08), Iceland (0.08; 95 percent CI = -0.02, 0.18), Belgium (0.07; 95 percent CI = -0.01, 0.14), France (0.08; 95 percent CI = -0.01, 0.16), Spain (0.05; 95 percent CI = -0.02, 0.11), Poland (0.06; 95 percent CI = -0.00, 0.13), Canada (0.08; 95 percent CI = -0.01, 0.18), the United States (0.07; 95 percent CI = -0.02, 0.17), and Japan (0.06; 95 percent CI = -0.01, 0.12).

Geographic Area. Eastern and Atlantic European countries had among the highest age-standardized amenable mortality rates in 2000 and steeper declines (-6.1 and -4.7, respectively) than did other geographic areas: Northern Europe -3.2, Central Europe -2.9, Southern Europe -2.8, North America -2.4, Middle East -3.0, East Asia -3.8, Oceania -3.0, and Latin America -1.7 (Figure 2). Compared with the OECD average, the average annual decrease was *larger* in the Atlantic and Eastern Europe; *smaller* in Central Europe, North America, Latin America, Middle East, and Oceania; and *neither smaller nor larger* in Northern Europe, Southern Europe, and East Asia (Table 2). Focusing on specific causes of amenable mortality, we found a significant association between geographic area and the reduction of amenable mortality from cardiovascular diseases, but not from cancers and other amenable conditions.

Diseases. Table 2 shows that the OECD average annual decline in amenable mortality during the 14-year period was -0.5 (95 percent CI = -0.6, -0.4) for cancers and -2.5 (95 percent CI = -3.0, -2.0) for diseases of the cardiovascular system, with significant differences among OECD countries (cancers:

Table 2: Estimated Annual Change in Amenable Age-Standardized Death Rates from All Causes, Cancers, Cardiovascular Diseases, and Other Conditions, in 32 OECD Countries Stratified by Geographic Area (2000–2013).

Geographic Area and Country	Average Annual Rates of Change (Slope) (95% CI)				Average Annual Decrease Compared with the Average*			
	All Causes	Cancers	CVD Diseases	Other Causes	All Causes	Cancers	CVD Diseases	Other Causes
Northern Europe	-3.2 (-3.7, -2.7)	-0.5 (-0.8, -0.3)	-2.2 (-2.4, -2.0)	-0.4 (-0.7, -0.2)	Neither smaller nor larger	Neither smaller nor larger	Smaller	Neither smaller nor larger
Denmark	-4.0 (-4.3, -3.6)	-1.0 (-1.1, -0.8)	-2.5 (-2.7, -2.3)	-0.5 (-0.7, -0.3)	Larger	Larger	Neither smaller nor larger	Neither smaller nor larger
Finland	-3.7 (-4.0, -3.4)	-0.3 (-0.4, -0.2)	-2.3 (-2.5, -2.1)	-1.0 (-1.1, -0.8)	Neither smaller nor larger	Smaller	Smaller	Larger
Iceland	-2.5 (-3.0, -1.9)	-0.3 (-0.5, -0.1)	-1.7 (-2.1, -1.3)	-0.3 (-0.6, 0.0)	Smaller	Smaller	Smaller	Neither smaller nor larger
Norway	-3.0 (-3.3, -2.7)	-0.7 (-0.8, -0.6)	-2.2 (-2.4, -2.0)	-0.3 (-0.4, -0.1)	Smaller	Larger	Smaller	Smaller
Sweden	-2.6 (-2.9, -2.2)	-0.4 (-0.5, -0.3)	-2.0 (-2.2, -1.8)	-0.2 (-0.4, 0.0)	Smaller	Smaller	Smaller	Smaller
Central Europe	-2.9 (-3.2, -2.5)	-0.6 (-0.7, -0.4)	-2.0 (-2.4, -1.6)	-0.4 (-0.5, -0.2)	Smaller	Neither smaller nor larger	Smaller	Smaller
Austria	-3.4 (-3.7, -3.1)	-0.8 (-0.9, -0.7)	-2.1 (-2.3, -1.9)	-0.5 (-0.7, -0.3)	Neither smaller nor larger	Larger	Smaller	Neither smaller nor larger
Belgium	-2.7 (-3.1, -2.4)	-0.5 (-0.7, -0.4)	-1.8 (-2.0, -1.5)	-0.5 (-0.7, -0.3)	Smaller	Neither smaller nor larger	Smaller	Neither smaller nor larger
France	-1.9 (-2.3, -1.6)	-0.5 (-0.6, -0.3)	-1.1 (-1.3, -0.8)	-0.3 (-0.5, -0.1)	Smaller	Neither smaller nor larger	Smaller	Smaller

Continued

Table 2. Continued

Geographic Area and Country	Average Annual Rates of Change (Slope) (95% CI)				Average Annual Decrease Compared with the Average*			
	All Causes	Cancers	CV Diseases	Other Causes	All Causes	Cancers	CV Diseases	Other Causes
Germany	-3.0 (-3.3, -2.7)	-0.7 (-0.8, -0.6)	-2.2 (-2.4, -2.0)	-0.2 (-0.4, 0.0)	Smaller	Larger	Smaller	Smaller
	-2.9 (-3.2, -2.6)	-0.4 (-0.5, -0.2)	-2.5 (-2.7, -2.3)	-0.1 (-0.3, 0.1) [†]	Smaller	Smaller	Neither smaller nor larger	Smaller
Netherlands	-3.2 (-3.5, -2.9)	-0.4 (-0.5, -0.3)	-2.3 (-2.5, -2.1)	-0.5 (-0.7, -0.4)	Smaller	Neither smaller nor larger	Smaller	Neither smaller nor larger
Atlantic Europe	-4.7 (-5.1, -4.2)	-0.7 (-0.8, -0.6)	-3.0 (-3.2, -2.8)	-1.0 (-1.6, -0.4)	Larger	Larger	Larger	Neither smaller nor larger
Ireland	-5.0 (-5.3, -4.7)	-0.7 (-0.9, -0.6)	-2.8 (-3.0, -2.6)	-1.4 (-1.6, -1.2)	Larger	Larger	Neither smaller nor larger	Larger
United Kingdom	-4.3 (-4.6, -3.9)	-0.6 (-0.7, -0.5)	-3.0 (-3.3, -2.8)	-0.6 (-0.8, -0.4)	Larger	Neither smaller nor larger	Larger	Neither smaller nor larger
Southern Europe	-2.8 (-3.7, -1.9)	-0.2 (-0.4, -0.1)	-2.1 (-2.8, -1.4)	-0.4 (-0.7, -0.2)	Neither smaller nor larger	Smaller	Neither smaller nor larger	Neither smaller nor larger
Greece	-2.3 (-2.6, -2.0)	-0.1 (-0.2, 0.1) [†]	-2.1 (-2.3, -1.9)	-0.2 (-0.4, 0.0)	Smaller	Smaller	Smaller	Smaller
Italy	-2.1 (-2.5, -1.8)	-0.4 (-0.5, -0.2)	-1.5 (-1.7, -1.3)	-0.3 (-0.5, -0.1)	Smaller	Smaller	Smaller	Smaller
Portugal	-4.4 (-4.6, -4.1)	-0.3 (-0.4, -0.2)	-3.3 (-3.5, -3.1)	-0.8 (-1.0, -0.6)	Larger	Smaller	Larger	Larger
Spain	-2.4 (-2.7, -2.1)	-0.3 (-0.4, -0.1)	-1.6 (-1.8, -1.4)	-0.5 (-0.7, -0.4)	Smaller	Smaller	Smaller	Neither smaller nor larger

Continued

Table 2. Continued

Geographic Area and Country	Average Annual Rates of Change (Slope) (95% CI)				Average Annual Decrease Compared with the Average*			
	All Causes	Cancers	CV Diseases	Other Causes	All Causes	Cancers	CV Diseases	Other Causes
Eastern Europe	-6.1 (-7.9, -4.4)	-0.7 (-1.0, -0.4)	-4.5 (-5.7, -3.3)	-0.9 (-1.5, -0.2)	Larger	Neither smaller nor larger	Larger	Neither smaller nor larger
Czech Republic	-5.4 (-5.7, -5.1)	-1.3 (-1.4, -1.2)	-3.7 (-3.9, -3.5)	-0.3 (-0.5, -0.2)	Larger	Larger	Larger	Smaller
Estonia	-10.8 (-11.1, -10.5)	-0.7 (-0.8, -0.5)	-7.7 (-7.9, -7.5)	-2.4 (-2.6, -2.2)	Larger	Larger	Larger	Larger
Hungary	-5.9 (-6.2, -5.6)	-0.6 (-0.7, -0.5)	-4.5 (-4.7, -4.3)	-0.7 (-0.9, -0.6)	Larger	Neither smaller nor larger	Larger	Larger
Poland	-4.4 (-4.7, -4.2)	-0.3 (-0.4, -0.2)	-3.9 (-4.1, -3.7)	-0.3 (-0.4, -0.1)	Larger	Smaller	Larger	Smaller
Slovakia	-5.6 (-6.1, -5.2)	-0.8 (-0.9, -0.6)	-4.5 (-4.8, -4.2)	-0.2 (-0.5, 0.0)†	Larger	Larger	Larger	Smaller
Slovenia	-4.5 (-4.9, -4.0)	-0.4 (-0.6, -0.2)	-2.8 (-3.2, -2.5)	-1.0 (-1.3, -0.8)	Larger	Neither smaller nor larger	Neither smaller nor larger	Larger
North America	-2.4 (-2.9, -1.9)	-0.6 (-0.6, -0.5)	-1.7 (-2.0, -1.4)	-0.2 (-0.3, 0.0)	Smaller	Neither smaller nor larger	Smaller	Smaller
Canada	-2.0 (-2.4, -1.5)	-0.5 (-0.7, -0.4)	-1.4 (-1.8, -1.1)	-0.1 (-0.3, 0.1)†	Smaller	Neither smaller nor larger	Smaller	Smaller
United States of America	-2.7 (-3.2, -2.2)	-0.6 (-0.7, -0.4)	-1.9 (-2.2, -1.6)	-0.3 (-0.5, 0.0)	Smaller	Neither smaller nor larger	Smaller	Smaller
Latin America	-1.7 (-3.2, -0.11)	-0.2 (-0.3, -0.2)	-1.0 (-2.3, 0.2)	-0.8 (-1.2, -0.3)	Smaller	Smaller	Smaller	Neither smaller nor larger

Continued

Table 2. Continued

Geographic Area and Country	Average Annual Rates of Change (Slope) (95% CI)				Average Annual Decrease Compared with the Average*			
	All Causes	Cancers	CVD Diseases	Other Causes	All Causes	Cancers	CVD Diseases	Other Causes
Chile	-3.0 (-3.5, -2.6)	-0.3 (-0.4, -0.1)	-2.0 (-2.3, -1.6)	-1.0 (-1.3, -0.8)	Smaller	Smaller	Smaller	Larger
Mexico	-0.8 (-1.2, -0.3)	-0.2 (-0.4, -0.1)	-0.1 (-0.4, 0.2) [†]	-0.4 (-0.7, -0.2)	Smaller	Smaller	Smaller	Neither smaller nor larger
Middle East Israel	-3.0 (-3.3, -2.7)	-0.6 (-0.7, -0.5)	-1.8 (-2.0, -1.7)	-0.5 (-0.6, -0.4)	Smaller	Larger	Smaller	Neither smaller nor larger
East Asia	-3.8 (-6.7, -0.8)	-0.1 (-0.2, 0.1)	-3.0 (-5.6, -0.4)	-0.6 (-0.9, -0.4)	Neither smaller nor larger	Smaller	Neither smaller nor larger	Neither smaller nor larger
Japan	-1.7 (-1.9, -1.4)	-0.1 (-0.2, 0.0)	-1.1 (-1.3, -0.9)	-0.4 (-0.6, -0.3)	Smaller	Smaller	Smaller	Neither smaller nor larger
South Korea	-5.9 (-6.2, -5.6)	-0.1 (-0.3, 0.0)	-4.8 (-5.0, -4.6)	-0.8 (-1.0, -0.7)	Larger	Smaller	Larger	Larger
Oceania	-3.0 (-3.4, -2.7)	-0.9 (-1.0, -0.8)	-1.9 (-2.3, -1.6)	-0.2 (-0.3, -0.2)	Smaller	Larger	Smaller	Smaller
Australia	-2.8 (-3.2, -2.4)	-0.9 (-1.0, -0.7)	-1.7 (-2.0, -1.4)	-0.3 (-0.5, -0.1)	Smaller	Larger	Smaller	Smaller
New Zealand	-3.3 (-3.7, -2.9)	-0.9 (-1.0, -0.7)	-2.2 (-2.4, -1.9)	-0.2 (-0.5, 0.0)	Neither smaller nor larger	Larger	Smaller	Smaller
Overall	-3.6 (-4.2, -2.9)	-0.5 (-0.6, -0.4)	-2.5 (-3.0, -2.0)	-0.5 (-0.7, -0.4)				

Note. For the sake of brevity, we report only the coefficients for the linear term in the regression model.
* Neither smaller nor larger means that the 95% confidence interval (CI) for that country's slope parameter overlaps the average value across all countries, whereas smaller and larger mean that the confidence interval does not overlap the average value, that is, the slope parameter is significantly smaller or larger than the average.
[†]The 95% CI crosses 0, indicating nonsignificant slope.

SD = 0.3, $p < .001$; cardiovascular diseases: SD = 1.4, $p < .001$). The declining trend in cancer-amenable SDRs was linear (coefficient of the quadratic term = 0.01; 95 percent CI = -0.00, 0.02; $p = .07$), whereas the decrease in cardiovascular disease SDRs slowed over time (0.10; 95 percent CI = 0.07, 0.12; $p < .001$), with significant differences among countries (SD = 0.05, $p < .001$). The average annual decrease compared with the OECD average for cardiovascular diseases was *larger* in all Atlantic and Eastern Europe; *smaller* in Northern and Central Europe, Northern and Latin America, Middle East, and Oceania; and *neither smaller nor larger* in Southern Europe and East Asia. For cancers, the average annual decrease compared with the OECD average was *larger* in Atlantic Europe, Middle East, and Oceania, and *smaller* in Southern Europe, Latin America, and East Asia.

Eastern and Atlantic European countries, which had declining slopes greater than the OECD average, had higher cardiovascular disease SDRs in 2000, whereas countries with relatively slow declines (range between -1.1 and -1.8) had low cardiovascular mortality rates in 2000. Similarly, the countries with slopes greater than the OECD average were those with higher cancer-amenable SDR in 2000 (≥ 30 per 100,000); the only exception was the United States, which started with a relatively low cancer-amenable SDR of 27 per 100,000 in 2000 and had a slope of -0.6. The only countries where some of the disease-specific mortality reductions were not statistically significant were Mexico (cardiovascular diseases), Greece (cancers), and Luxembourg, Slovakia, and Canada (other causes).

All OECD countries experienced a slowdown in the reduction of cardiovascular disease SDRs during the 14-year period, with the exception of Denmark (coefficient for the quadratic term = 0.04; 95 percent CI = -0.02, 0.09), Belgium (0.05; 95 percent CI = -0.00, 0.11), France (0.06; 95 percent CI = -0.01, 0.12), Spain (0.03; 95 percent CI = -0.02, 0.08), United States (0.06; 95 percent CI = -0.01, 0.13), Chile (0.07; 95 percent CI = -0.00, 0.14), and Japan (0.03; 95 percent CI = -0.02, 0.08). The countries where this slowdown was more pronounced were Ireland (0.21; 95 percent CI = 0.14, 0.28), Czech Republic (0.20; 95 percent CI = 0.15, 0.25), and Austria (0.19; 95 percent CI = 0.14, 0.23).

DISCUSSION

The aim of our study was to update the amenable mortality rates at 2013 (or last available year) in 32 OECD countries, to describe the annual variations in

mortality amenable to health care during 2000–2013, to determine whether these changes were constant over time, and to evaluate their association with various geographic areas. Our results showed a clear decline in amenable SDRs in all 32 OECD countries between 2000 and 2010/2013. This result confirms that previously documented trends are continuing to 2010/2013 (Charlton and Velez 1986; Boys, Forster, and Józán 1991; Kjellstrand, Kovithavongs, and Szabo 1998; Nolte and McKee 2008).

Inferential statistical analysis provided information on the scale of decline by showing the annual change in amenable SDRs. All 32 OECD countries experienced a significant decline in amenable mortality rates for all causes with an average annual rate of change of -3.6 percent. This finding is in agreement with that of Gay et al. (2011), who measured the average annual change in amenable mortality in 31 OECD countries between 1997 and 2007 and concluded that amenable mortality declined in all OECD countries, with an average annual decline of 3.7 percent. Although amenable SDRs have fallen in all geographic areas between 2000 and 2013, the scale of improvement has varied substantially across geographic areas: Latin America experienced the slowest decline and Eastern Europe and Atlantic Europe the most rapid decline between 2000 and 2010/2013. As a result, amenable mortality rates in Latin America were high in 2010/2013, in comparison with the average rate of all areas. One of the reasons for the low slope, supported by previous studies (Arah et al. 2005; Nolte and McKee 2011), may be the lack of universal health care coverage. In Mexico and Chile, coverage has grown in recent years, but it was not until 2011 that nearly 90 percent of the population was covered (Organisation for Economic Co-operation and Development [OECD] 2011, 2013a).

In 2013, the amenable SDR in Eastern Europe, as Velkova, Wolleswinkel-van den Bosch, and Mackenbach (1997) previously demonstrated, was still relatively high compared with other areas. Nevertheless, large gains were seen in comparison with geographic areas where the amenable SDR was lower: in 2000, the gap was 94 deaths for 100,000 (compared with Southern Europe and Oceania areas), whereas in 2013 it was 76 (compared with Oceania). The high slope in Eastern Europe, and especially in Estonia, may have been facilitated by the rapid implementation of innovations and advances in treatment. Mackenbach et al. (2013) showed that amenable mortality rates in Estonia started to drop from 2000 because Estonia was able to adopt many new interventions only after independence in 1991. In a European project (Amenable mortality in the European Union: toward better indicators for the effectiveness of health systems [AMIEHS] 2011), the impact of new interventions that

are likely to contribute to reduce mortality from amenable causes of death was analyzed in seven European countries (UK, The Netherlands, Germany, France, Spain, Sweden, Estonia). These interventions included treatments for cardiovascular disease and cancer, and cancer screening. This project showed that the introduction of innovations occurred later in Estonia (1990s and 2000s) than in the other countries (1980s and early 1990s). Additionally, screening programs started in the 2000s in certain Eastern European countries (OECD 2013b) with delays in comparison to other Eastern European countries. These delays in implementing guidelines and protocols may have contributed to the high slope in Eastern Europe. Böhm et al. (2013) concluded that the health systems of Eastern European countries are related by their common history, sharing a Semashko system during the Soviet era. Treatment guidelines were not part of the medical culture during this time, but they have been adopted more recently.

By 2013, amenable mortality rates in Atlantic Europe grew closer to levels of the other areas (except Latin America and Eastern Europe) that were lower in 2000. These results appear to reflect improvements in uptake of medical and surgical treatments of cardiovascular diseases, as well as changes in risk factors such as smoking. This interpretation is consistent with Bajekal et al. (2012), who found that medical and surgical treatments were responsible for approximately half of the decline in deaths from coronary heart disease (a subgroup of cardiovascular diseases) between 2000 and 2007 in England.

Our results also suggest that amenable SDRs are reaching a level of stability in most advanced countries. Only Denmark, Iceland, Belgium, France, Spain, Poland, Canada, and Japan did not demonstrate a decreasing slope of amenable mortality over time. This finding suggests that the health care systems of the most advanced countries may find it increasingly difficult to achieve additional gains (Nolte and McKee 2012). This interpretation gains some support from a study of the annual decline in amenable mortality for four conditions in seven European countries (Mackenbach et al. 2013).

Our study has its strengths and weaknesses. We updated the absolute levels of mortality from amenable conditions, but we also estimated the rate of mortality decline. This second measure may be a better indicator of the performance of national health systems, because the rate of decline is less likely to be biased by such confounding factors as baseline health risks and exposures.

Our analysis was conducted at the country level only and did not disaggregate mortality by ethnicity, race, or socioeconomic characteristics; thus, potentially large variations within populations may be concealed. Evidence

from New Zealand, Australia, and Europe points to higher levels of amenable mortality in indigenous and immigrant populations compared with non-indigenous and native-born populations (Westerling and Rosén 2002; Page, Tobias, and Glover 2006; Stirbu et al. 2006). Studies from the United States and Europe also observed higher levels of amenable mortality among people disadvantaged in terms of race or socioeconomic status (Schwartz et al. 1990; Westerling, Gullberg, and Rosén 1996; Macinko and Elo 2009).

In addition, our analysis did not disaggregate amenable mortality by individual causes, thereby potentially concealing variations among countries. In previous studies, the starting levels and trends of individual causes of death varied greatly across 17 European countries and 6 other countries, which were selected to provide a variety of forms of health care delivery (Charlton and Velez 1986; Treurniet, Boshuizen, and Harteloh 2004).

In conclusion, our study revealed the following: (1) the declining trend of amenable mortality rates continued to 2013 (or last available year); (2) amenable SDRs declined during 2000–2013 in all of the geographic areas and countries, but at different rates; and (3) there was a slowdown in the amenable mortality rate reduction. If amenable mortality is defined as “premature death that should not occur in the presence of timely and effective health care,” then our results should prompt further studies to monitor trends over time and investigate the specific causes that drive the slowing of the decrease in amenable deaths in most national health systems.

ACKNOWLEDGMENTS

Joint Acknowledgment/Disclosure Statement: Drs. Gianino and Siliquini are employed by the University of Turin’s Department of Public Health Sciences and Pediatrics, Drs. Lenzi and Fantini are employed by the University of Bologna’s Department of Biomedical and Neuromotor Sciences, Dr. Muça is a medical resident in Public Health and Preventive Medicine at the University of Turin’s Department of Public Health Sciences and Pediatrics, and Drs. Ricciardi and Damiani are employed by the Catholic University of the Sacred Heart’s Department of Public Health. In January 2015, Dr. Ricciardi was nominated President of the National Institute of Health (Istituto Superiore di Sanità), a public institution which serves as a major clearing house for technical and scientific information on public health-related issues. These institutions had no role in the design, conduct, analysis, interpretation, or presentation of the study.

Disclosures: None.

Disclaimers: None.

REFERENCES

- Amenable Mortality in the European Union: Toward Better Indicators for the Effectiveness of Health Systems [AMIEHS]. 2011. "Avoidable Mortality in the European Union" [accessed on September 1, 2015]. Available at <http://amiehs.lshtm.ac.uk/publications/reports/AMIEHS%20final%20report%20VOL%20I.pdf>
- Arah, O. A., G. P. Westert, D. M. Delnoij, and N. S. Klazinga. 2005. "Health System Outcomes and Determinants Amenable to Public Health in Industrialized Countries: A Pooled, Cross-Sectional Time Series Analysis." *BMC Public Health* 5 (1): 81.
- Bajekal, M., S. Scholes, H. Love, N. Hawkins, M. O'Flaherty, R. Raine, and S. Capewell. 2012. "Analysing Recent Socioeconomic Trends in Coronary Heart Disease Mortality in England, 2000-2007: A Population Modelling Study." *PLoS Medicine* 9 (6): e1001237.
- Böhm, K., A. Schmid, R. Götze, C. Landwehr, and H. Rothgang. 2013. "Five Types of OECD Healthcare Systems: Empirical Results of a Deductive Classification." *Health Policy* 113 (3): 258–69.
- Boys, R. M., D. P. Forster, and P. Józan. 1991. "Mortality from Causes Amenable and Non-Amenable to Medical Care: The Experience of Eastern Europe." *British Medical Journal* 303 (6807): 879–83.
- Charlton, J., and R. Velez. 1986. "Some International Comparisons of Mortality Amenable to Medical Intervention." *British Medical Journal* 292 (6516): 295–301.
- Commonwealth Fund. 2011. "State Scorecard" [accessed on February 13, 2015]. Available at <http://www.commonwealthfund.org/>
- Gay, J., V. Paris, M. Devaux, and M. deLooper. 2011. *Mortality Amenable to Health Care in 31 OECD Countries: Estimates and Methodological Issues*. Paris: OECD.
- Holland, W. 1988. *European Community Atlas of "Avoidable Death"*. Oxford, England: Oxford University Press.
- Kjellstrand, C. M., C. Kovithavongs, and E. Szabo. 1998. "On the Success, Cost and Efficiency of Modern Medicine: An International Comparison." *Journal of Internal Medicine* 243 (1): 3–14.
- Lavergne, M. R., and K. McGrail. 2013. "What, If Anything, Does Amenable Mortality Tell Us about Regional Health System Performance?" *Healthcare Policy* 8 (3): 79–90.
- Macinko, J., and I. T. Elo. 2009. "Black-White Differences in Avoidable Mortality in the USA, 1980-2005." *Journal of Epidemiology and Community Health* 63 (9): 715–21.
- Mackenbach, J. P. 1996. "The Contribution of Medical Care to Mortality Decline: McKeown Revisited." *Journal of Clinical Epidemiology* 49 (11): 1207–13.
- Mackenbach, J. P., R. Hoffmann, B. Khoshaba, I. Plug, G. Rey, R. Westerling, K. Pärna, E. Jougl, J. Alfonso, C. Looman, and C. M. McKee. 2013. "Using 'Amenable Mortality' as Indicator of Healthcare Effectiveness in International

- Comparisons: Results of a Validation Study." *Journal of Epidemiology and Community Health* 67 (2): 139–46.
- National Health Service [NHS]. 2010. "The NHS Outcomes Framework 2011/12" [accessed on September 1, 2015]. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/213789/dh_123138.pdf
- Nolte, E., and C. M. McKee. 2003. "Measuring the Health of Nations: Analysis of Mortality Amenable to Health Care." *British Medical Journal* 327 (7424): 1129.
- . 2004. *Does Health Care Save Lives? Avoidable Mortality Revisited*. London: The Nuffield Trust.
- . 2008. "Measuring the Health of Nations: Updating an Earlier Analysis." *Health Affairs (Millwood)* 27 (1): 58–71.
- . 2011. "Variations in Amenable Mortality—Trends in 16 High-Income Nations." *Health Policy* 103 (1): 47–52.
- . 2012. "In Amenable Mortality—Deaths Avoidable through Health Care—Progress in the US Lags That of Three European Countries." *Health Affairs (Millwood)* 31 (9): 2114–22.
- Organisation for Economic Co-operation and Development [OECD]. 2011. "Health at a Glance 2011: OECD Indicators" [accessed on September 3, 2015]. Available at: http://dx.doi.org/10.1787/health_glance-2011-en
- Organisation for Economic Co-operation and Development [OECD]. 2013a. "Health at a Glance 2013: OECD Indicators" [accessed on September 1, 2015]. Available at http://dx.doi.org/10.1787/health_glance-2013-en
- Organisation for Economic Co-operation and Development [OECD]. 2013b. "Cancer Care: Assuring Quality to Improve Survival. Health Policy Studies" [accessed on September 3, 2015]. Available at <http://dx.doi.org/10.1787/9789264181052-en>
- Page, A., M. Tobias, and J. Glover. 2006. *Australian and New Zealand Atlas of Avoidable Mortality*. Adelaide: PHIDU, University of Adelaide.
- Poikolainen, K., and J. Eskola. 1986. "The Effect of Health Services on Mortality: Decline in Death Rates from Amenable and Non-Amenable Causes in Finland, 1969–1981." *Lancet* 1 (8474): 199–202.
- . 1995. "Regional and Social Class Variation in the Relative Risk of Death from Amenable Causes in the City of Helsinki, 1980–1986." *International Journal of Epidemiology* 24 (1): 114–8.
- Rossi, S., P. Balli, R. Capocaccia, M. Caldora, E. Corrani, P. Minicozzi, D. Pierannunzio, M. Santaquilani, A. Trama, C. Allemani, A. Belot, C. Buzzoni, M. Lorez, and R. De Angelis. 2015. "The EURO CARE-5 Study on Cancer Survival in Europe 1999–2007: Database, Quality Checks and Statistical Analysis Methods." *European Journal of Cancer* 51 (5): 2104–19.
- Rustein, D. D., W. Berenberg, T. C. Chalmers, C. G. Child, A. P. Fishman, and E. B. Perrin. 1976. "Measuring the Quality of Medical Care. A Clinical Method." *New England Journal of Medicine* 294 (11): 582–8.
- Schwartz, E., V. Y. Koffe, M. Rivo, and R. V. Tuckson. 1990. "Black/White Comparisons of Deaths Preventable by Medical Intervention: United States and the District of Columbia 1980–1986." *International Journal of Epidemiology* 19 (3): 591–8.

- Stirbu, I., A. E. Kunst, V. Bos, and J. P. Mackenbach. 2006. "Differences in Avoidable Mortality between Migrants and the Native Dutch in The Netherlands." *BMC Public Health* 6 (1): 78.
- Stirbu, I., A. E. Kunst, M. Bopp, M. Leinsalu, E. Regidor, S. Esnaola, G. Costa, P. Martikainen, C. Borrell, P. Deboosere, R. Kalediene, J. Rychtarikova, B. Artnik, and J. P. Mackenbach. 2010. "Educational Inequalities in Avoidable Mortality in Europe." *Journal of Epidemiology and Community Health* 64 (10): 913–20.
- Tobias, M., and G. Jackson. 2001. "Avoidable Mortality in New Zealand, 1981–97." *Australian and New Zealand Journal of Public Health* 25 (1): 12–20.
- Tobias, M., and L. C. Yeh. 2009. "How Much Does Health Care Contribute to Health Gain and to Health Inequality? Trends in Amenable Mortality in New Zealand 1981–2004." *Australian and New Zealand Journal of Public Health* 33 (1): 70–8.
- Treurniet, H. F., H. C. Boshuizen, and P. P. Harteloh. 2004. "Avoidable Mortality in Europe (1980–1997): A Comparison of Trends." *Journal of Epidemiology and Community Health* 58 (4): 290–5.
- United Nations [UN]. 2014. "World Population Prospects, the 2012 Revision" [accessed on December 3, 2015]. Available at <http://www.un.org/en/development/desa/publications/world-population-prospects-the-2012-revision.html>
- Velkova, A., J. H. Wolleswinkel-van den Bosch, and J. P. Mackenbach. 1997. "The East-West Life Expectancy Gap: Differences in Mortality from Conditions Amenable to Medical Intervention." *International Journal of Epidemiology* 26 (1): 75–84.
- Westerling, R., A. Gullberg, and M. Rosén. 1996. "Socioeconomic Differences in 'Avoidable' Mortality in Sweden." *Scandinavian Journal of Public Health* 31 (5): 342–9.
- Westerling, R., and M. Rosén. 2002. "'Avoidable' Mortality among Immigrants in Sweden." *European Journal of Public Health* 12 (4): 279–86.
- World Bank. 2015. "How Does the World Bank Classify Countries?" [accessed on December 3, 2015]. Available at <https://datahelpdesk.worldbank.org/knowledgebase/articles/378834-how-does-the-world-bank-classify-countries>
- World Health Organization [WHO]. 2014. "Mortality Database" [accessed on June 3, 2016]. Available at http://www.who.int/healthinfo/mortality_data/en/

SUPPORTING INFORMATION

Additional supporting information may be found in the online version of this article:

Appendix SA1: Author Matrix.

Appendix S1: List of 32 OECD Countries.

Appendix S2: Nolte and McKee's List of Causes of Death Considered Amenable to Health Care.