35 Hamlin MJ, Yule E, Elliot CA, et al. Long-term effectiveness of the New Zealand Green Prescription primary health care exercise initiative. *Public Health* 2016;140: 102–8. Available at: https://linkinghub.elsevier.com/retrieve/pii/S0033350616301834 (19 August 2019, date last accessed).

36 Harrison RA, Roberts C, Elton PJ. Does primary care referral to an exercise programme increase physical activity one year later? A randomized controlled trial. *J Public Health* 2005;27:25–32.

37 van Uffelen JGZ, Khan A, Burton NW. Gender differences in physical activity motivators and context preferences: a population-based study in people in their sixties. *BMC Public Health* 2017;17:624.

38 Hernandez-Boussard T, Monda KL, Crespo BC, Riskin D. Real world evidence in cardiovascular medicine: assuring data validity in electronic health record-based studies. *J Am Med Inform Assoc* 2019;26:1189–94. Available at: http://www.ncbi.nlm.nih.gov/pubmed/31414700 (19 August 2019, date last accessed).

39 Violán C, Foguet-Boreu Q, Fernández-Bertolín S, et al. Soft clustering using real-world data for the identification of multimorbidity patterns in an elderly population: cross-sectional study in a Mediterranean population. *BMJ Open* 2019;9:e029594.

40 Guisado-Clavero M, Violán C, López-Jimenez T, et al. Medication patterns in older adults with multimorbidity: a cluster analysis of primary care patients. *BMC Fam Pract* 2019;20:82.

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The great convergence? Mortality in Ireland and Europe, 1956–2014

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Background: Until recently, Irish age-standardized mortality rates (ASMRs) were amongst the highest in the EU-15. This study examines changes in ASMRs in Ireland from 1956 to 2014. **Methods:** Using data from the World Health Organization Mortality Database, we compare ASMRs in Ireland to other EU-15 countries from 1956 to 2014. ASMRS are used to plot the relative ranking of Ireland within the EU-15, and illustrate trends in which Ireland diverged with, and converged to, the EU-15 average. ASMRS are estimated across sex, age groups (15–64 and 65+ years) and cause of death. **Results:** Between 1956 and 1999, ASMRs in Ireland were amongst the highest in the EU-15. ASMRs in Ireland saw slower improvements during this period as compared to other EU-15 countries. However, post-2000, a sharp reduction in Irish ASMRs resulted in an accelerated convergence to the EU-15 average. As a consequence of improvements in ASMRs between 2000 and 2014, there were an estimated 15 300 fewer deaths in 2014. The majority of these averted deaths were due to lower mortality rates for diseases of the circulatory system and respiratory system. **Conclusions:** Rather than converging to the EU-15 average during the latter half of the 20th century, there was a divergence in ASMRs between Ireland and the EU-15. However, in recent years, Ireland experienced accelerated improvements in mortality rates with large reductions in mortality observed for diseases of the circulatory system and respiratory system, especially amongst older people.

Introduction

Significant improvements in mortality rates and life expectancy in Europe occurred throughout the 20th century. Between 1900 and 2008, average life expectancy in Europe increased from 43.5 to 73.8 years for males and from 45.8 to 80.4 years for females.[1] These improvements in life expectancy and mortality reductions have been attributed to a variety of factors including higher incomes,[1,2] improvements in medical treatment,[3–5] lifestyle changes, such as reduced smoking prevalence,[6] and environmental factors including improved sanitation.[7] Convergence in mortality between countries has also occurred.[1,6,8] While mortality rates between European countries saw sharp convergence from the mid-1970s, Ireland was much slower in converging to its European peers.

In the post-WWII period, while Ireland trailed its European neighbours in terms of childhood mortality,[7,9] overall mortality rates and life expectancy in Ireland matched, or were lower than, those of other western European countries, including the UK. However, between the 1960s and 1980s, Irish mortality rates and life expectancy essentially plateaued, with Ireland consistently having amongst the highest mortality rates in the EU-15.[10] Mortality rates began to fall in Ireland in the 1980s and there was an accelerated rate of reduction from the mid-1990s.[11] In recent years, Ireland has been shown to be consistently among the best performers in mortality reductions. In a study of adults aged 0–74 years in selected OECD countries, Ireland had the highest rates of amenable mortality in 1997/98 but saw a reduction of 20% over the next decade.[12,13] More recent evidence has shown that these mortality improvements, relative to other OECD countries, continued to 2015,[14] with reductions in cardiovascular disease, in particular, contributing to recent mortality improvements.[15,16]

This study builds upon the recent literature on Irish mortality by examining mortality in Ireland and the EU-15 between 1956 and 2014 using age-standardized mortality rates (ASMRs). The analysis explores ASMRs across sex, cause of death and age groups to identify where Ireland lagged behind its European neighbours initially, and where the largest improvements in mortality have occurred. The study also quantifies the effect of recent improvements in mortality between 2000 and 2014 in terms of potential 'deaths averted'.

Methods

This study examines ASMRs for EU-15 countries from 1956 to 2014. ASMRs are estimated across sex, age groups and causes of death.

ASMRs for Ireland are compared to an EU-15 country average for each year.

Data sources

Mortality and population data from the World Health Organization (WHO) Mortality Database for the years 1956–2014 are included in the analyses. This database includes all deaths registered by national death registration systems during these years, with deaths partitioned by age group (<1; 1–4; . . . . .; 80–84; 85+), sex and primary cause of death. In some years, data were missing for Ireland (2010), Luxembourg (1956–59; 1961–64) and Portugal (2004–06). Luxembourg was not included in the missing years; mortality data for Ireland for 2010 were obtained from the Central Statistics Office, while mortality rates for Portugal from 2004 to 2006 were linearly interpolated from surrounding years. We examine EU-15 countries only in this analysis, as differences remain between EU-15 and newer accession states in terms of health and mortality outcomes.[8] Data on West Germany are included for Germany pre-1990.

Within the WHO Mortality Database primary cause of death is classified using the International Classification of Diseases (ICD) Revisions 7–10. While newer ICD revisions replaced previous versions during the period examined, generally countries transferred to newer revisions at similar points in time (see Supplementary appendix table A1). While the move from ICD-9 to ICD-10 has resulted in a change to the number of deaths allocated to some chapters,[17,18] comparability for disease classification across revisions is high. Analyses from Canada found that the relative proportion of deaths among chapters had not changed in the move from ICD-9 to ICD-10 and the largest proportion of deaths continue to be classified to the chapters on diseases of the circulatory system, followed by those deaths classified to the chapter on malignant neoplasms.[17] Causes of death categories are:

- accidents, poisonings and violence (external cause),
- diseases of the circulatory system,
- diseases of the digestive system,
- diseases of the nervous system and sense organs,
- diseases of the respiratory system,
- infective and parasitic diseases,
- malignant neoplasms (cancers),
- mental disorders,
- perinatal conditions,
- symptoms, senility and ill-defined conditions and
- all other causes.

The 'All Other Causes' category captures deaths not covered by the other categories. The ICD codes for each cause of death are listed in Supplementary appendix table A2.

Age-standardized mortality rates

ASMRs were calculated using the 1976 European Standard Population (ESP):

$$\text{ASMR} = \frac{\sum(M_k P_k)}{\sum P_k}$$

where M_k is the crude mortality rate per 100 000 persons for 5-years age group k, P_k is the ESP in group k. While ASMRs are estimated for all ages, in order to examine difference across age categories, we also estimate ASMRs for the 15–64 years age category and 65+ age category separately. We estimate all-cause ASMRs and ASMRs for the three main causes of death during this period (see Supplementary appendix figure A1): circulatory disease, malignant neoplasms (cancer) and respiratory disease. In addition to being the main causes of death, we also concentrate on these three aggregated disease classifications to mitigate, as far as possible, the impact of ICD revision changes on disease classification (e.g. diseases of circulatory disease group cardiovascular disease and stroke, malignant neoplasm groups all malignant cancer). When codes are compared across ICD revisions, these conditions remained consistently coded. The 1976 ESP was chosen due to the years examined (1956–2014), with ASMR ranking of countries similar with the 2013 ESP.[19]

In the analysis, ASMRs in Ireland are plotted against other EU-15 countries as well as the EU-15 country average. These plots illustrate the relative ranking of Ireland within the EU-15 and illustrate where Ireland diverged with, and converged to, the EU-15 average. The EU-15 average ASMRs are estimated by taking the simple unweighted average of ASMRs across EU-15 countries annually.

To illustrate in greater detail changes in mortality rates in Ireland between 2000 and 2014, analyses presented in the Supplementary appendix compare the estimated additional number of deaths ('deaths averted') that would have occurred in 2014 if mortality rates from 2000 were applied to the 2014 population. These analyses applied the crude mortality rates for each cause of death and age group from 2000 to the 2014 Irish population, and subtracted the actual number of deaths that occurred by cause of death and age group in 2014. These analyses aid in the interpretation of the specific age groups and causes of deaths responsible for the largest change in Irish mortality in recent years.

Results

Figure 1 plots all-cause ASMRs across EU-15 countries, and the EU-15 average, from 1956 to 2014. Ireland's all-cause male ASMR was similar to the EU-15 average in 1956. However, between 1956 and 1979, Ireland and the EU-15 diverged, with ASMRs in Ireland plateauing during this period. Between 1979 and the early 2000s, ASMRs for males in Ireland were the highest, or amongst the highest, in the EU-15 for all ages and for the 65+ age category. Between 2000 and 2014, Ireland's male ASMR converged to the EU-15 average and the male all-cause ASMR reduced by 37% in Ireland compared to the EU-15 average reduction of 28%. Notably, as ASMRs within the 15–64 age category in Ireland virtually matched the EU-15 average for the full period, the sharp reduction in ASMRs in Ireland since 2000 has been driven by improvements in the 65+ age category.

Ireland's all-cause female ASMR was much higher than the EU-15 average for almost every year of the period studied. Between 1956 and 1979, Ireland's and the EU-15 average female ASMR reduced at similar rates. Between 2000 and 2014, Ireland's female ASMR converged to close to the EU-15 average. Between 2000 and 2014, Ireland's female ASMR reduced by 32% while the EU-15 average reduced by 24%.

Interpreting figure 1 results further, 48% and 33% of the mortality improvements in Ireland for males and females, respectively, between 1956 and 2014 occurred since 2000. As shown in Supplementary appendix tables A3 and A4, the ASMR reductions since 2000 equate to an estimated 8900 and 6400 fewer deaths ('deaths averted') for males and females, respectively, than would have been expected if 2000 rates still applied. The largest number of deaths were averted at older ages.

Figure 2 plots diseases of the circulatory system ASMRs. Ireland's circulatory system disease ASMR was the highest in the EU-15 for both males and females, for almost every year of the period. A slight divergence between Ireland and the EU-15 average, especially in the 65+ age category, was observed in earlier years. Ireland converged to the EU-15 average ASMR in recent years, with convergence occurring earlier for females. By 2014, circulatory disease ASMRs for both sexes and each age group in Ireland matched the EU-15 average. Between 2000 and 2014, Ireland's circulatory system disease ASMRs reduced by 53% and 51% for males and females, respectively, while the EU-15 average reduced by 43–44%. The reduction in ASMRs for diseases of the circulatory system since 2000 accounted for ~60% of

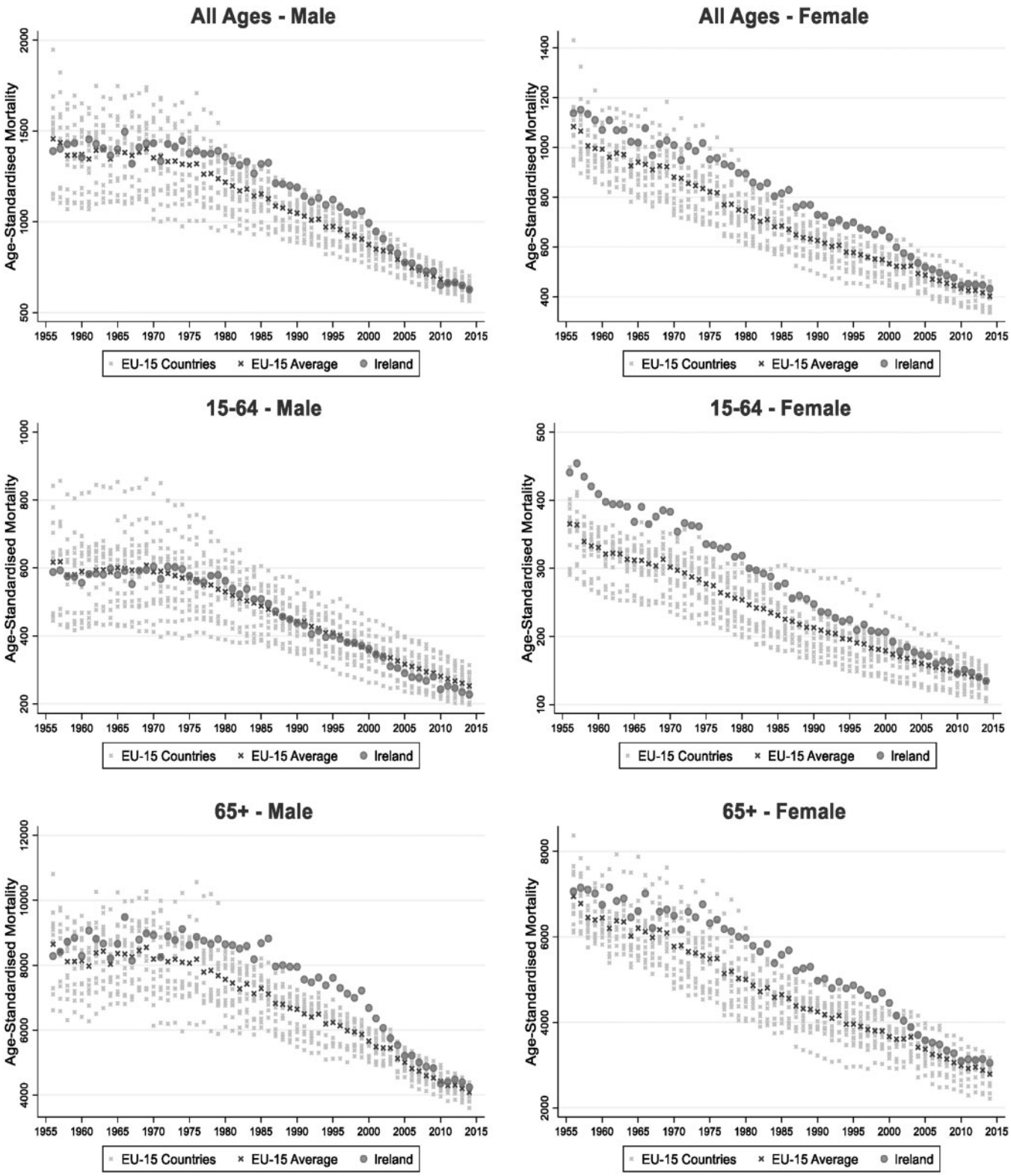

Figure 1 Age-standardized all-cause mortality rates per 100 000 across sex and age categories: 1956–2014

the estimated 'deaths averted' in Ireland in 2014 (Supplementary appendix tables A3 and A4).

Figure 3 plots malignant neoplasms (cancer) ASMRs and illustrates a more nuanced and complex situation compared to the results in figures 1 and 2. The male cancer ASMR in Ireland was lower in the earlier years but matched the EU-15 average in recent years. ASMRs in the 15–64 age category were consistently below the EU-15 average. However, female cancer ASMRs in Ireland, while matching the EU-15 average in 1956, differed considerably from the EU-15 average in most years examined. From 1965, the Irish female ASMR was consistently higher than the EU-15 average, and for many years was the highest in the EU-15. While there has been a slight convergence towards the EU-15 average for those aged 15–64 in recent years, overall female cancer ASMRs in 2014 in Ireland were the joint highest in the EU-15. Therefore, as Supplementary appendix tables A3 and A4 show, cancer mortality improvements explain a small proportion of the deaths averted in Ireland since 2000, especially for females.

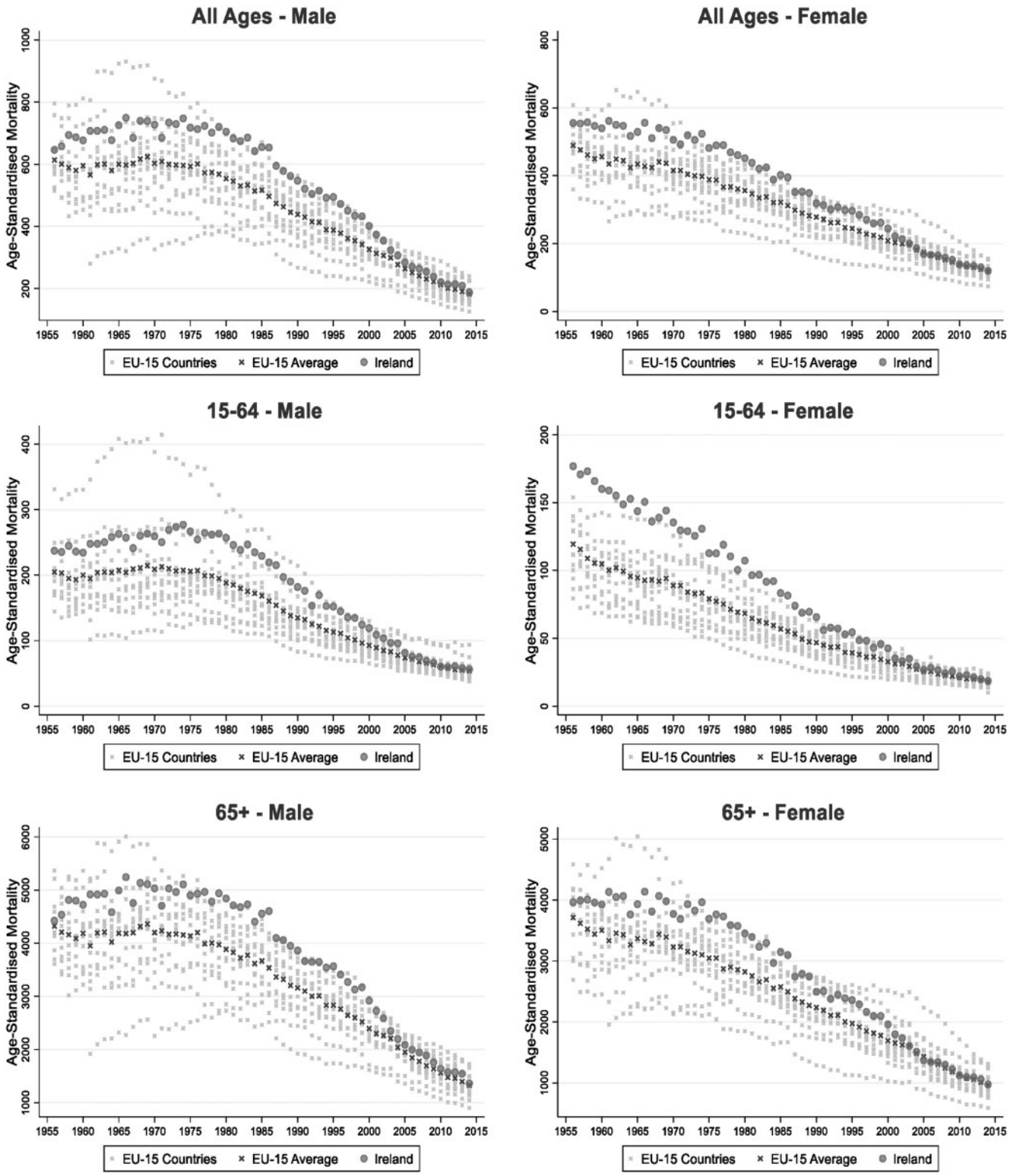

Figure 2 Age-standardized circulatory disease mortality rates per 100 000 across sex and age categories: 1956–2014

Figure 4 plots respiratory disease ASMRs. For both males and females, Ireland's respiratory disease ASMRs were similar to the EU-15 average in 1956. However, for much of the period, respiratory disease ASMRs in Ireland were the highest in the EU-15, Irish ASMRs twice as high as the EU-15 average in some years. A convergence to the EU-15 average began in the late 1990s and between 2000 and 2014, Ireland's respiratory disease ASMR halved. In the same period, the EU-15 average reduced by 38% and 32% for males and females, respectively. The reduction in respiratory disease ASMRs since 2000 accounted for ∼21% and 27% of the estimated 'deaths averted' (Supplementary appendix tables A3 and A4) for males and females, respectively. Ireland still lags the EU-15 average, especially for those aged 65+ where the respiratory disease ASMR remains the highest in the EU-15.

Discussion

Between 1956 and 1999, Ireland had the highest, or amongst the highest ASMRs in the EU-15. ASMRs were much higher than the EU-15 average during this period for diseases of the circulatory

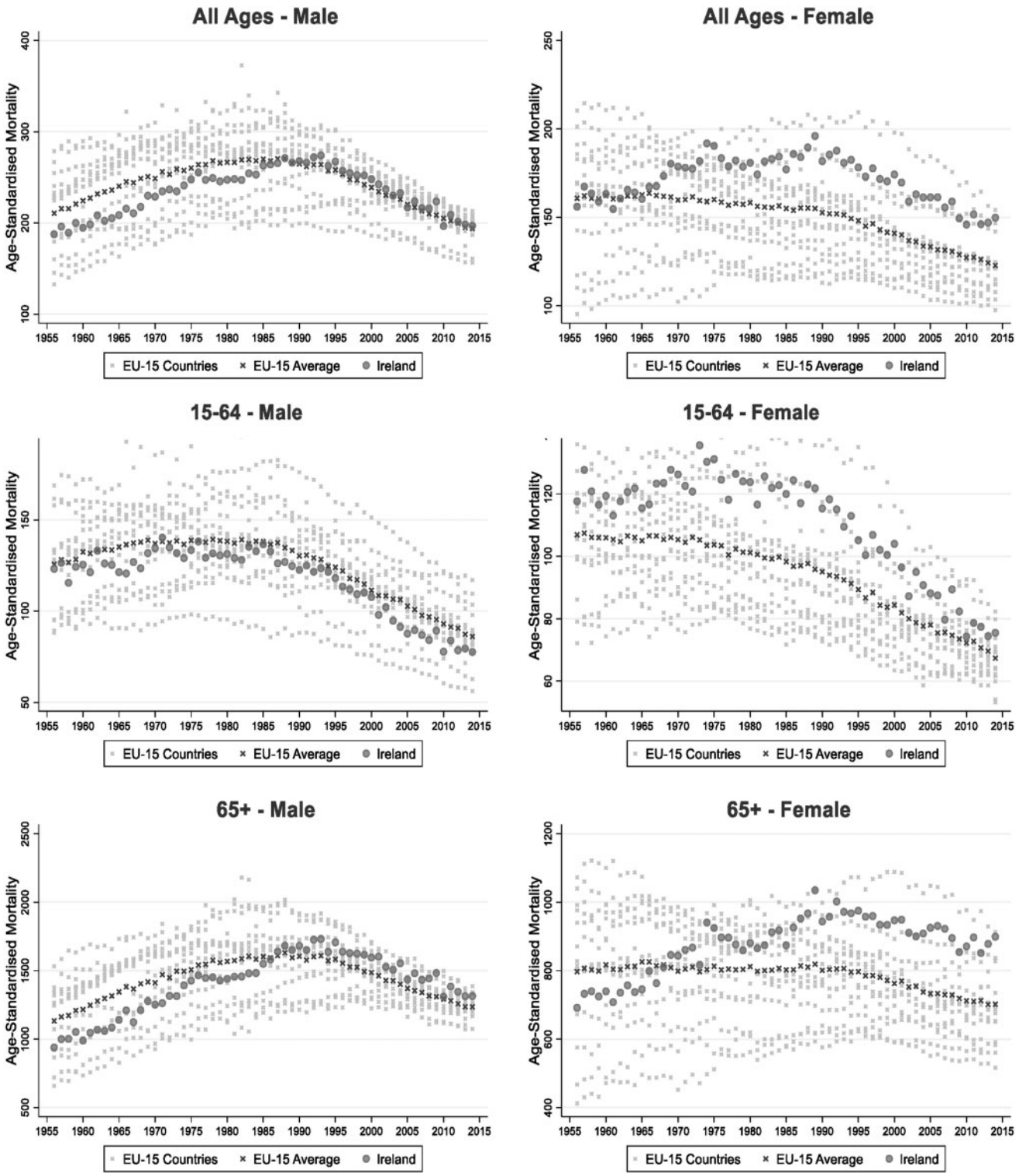

Figure 3 Age-standardized malignant neoplasm (cancer) mortality rates per 100 000 across sex and age categories: 1956–2014

system, female cancers and respiratory disease in particular. Despite previous literature finding a convergence of mortality across countries at the end of the 20th century, we show that rather than experiencing a convergence, there was a divergence in mortality between Ireland and EU-15 countries until recently. It was not until 2000 when sharp reductions in ASMRs began to occur in Ireland that Irish mortality rates converged to the EU-15 average. This pattern was not observed in other EU-15 countries where convergence occured much earlier.

To contextualize the dramatic reduction in Irish mortality in recent years, improvements in ASMRs post-2000 accounted for 48% and 30% of the total reductions observed over the full 1956–2014 period for males and females, respectively. Furthermore, in 2014, there were an estimated 15 300 fewer deaths in Ireland than would have been the case if ASMRs remained at 2000 levels. The analysis shows that the majority of these averted deaths occurred at older ages and were seen for diseases of the circulatory system, such as stroke and cardiovascular disease and respiratory disease. Improvements in cancer mortality accounted for a lower proportion of estimated deaths averted during this period than diseases of the circulatory system and respiratory disease. However, 14% of averted

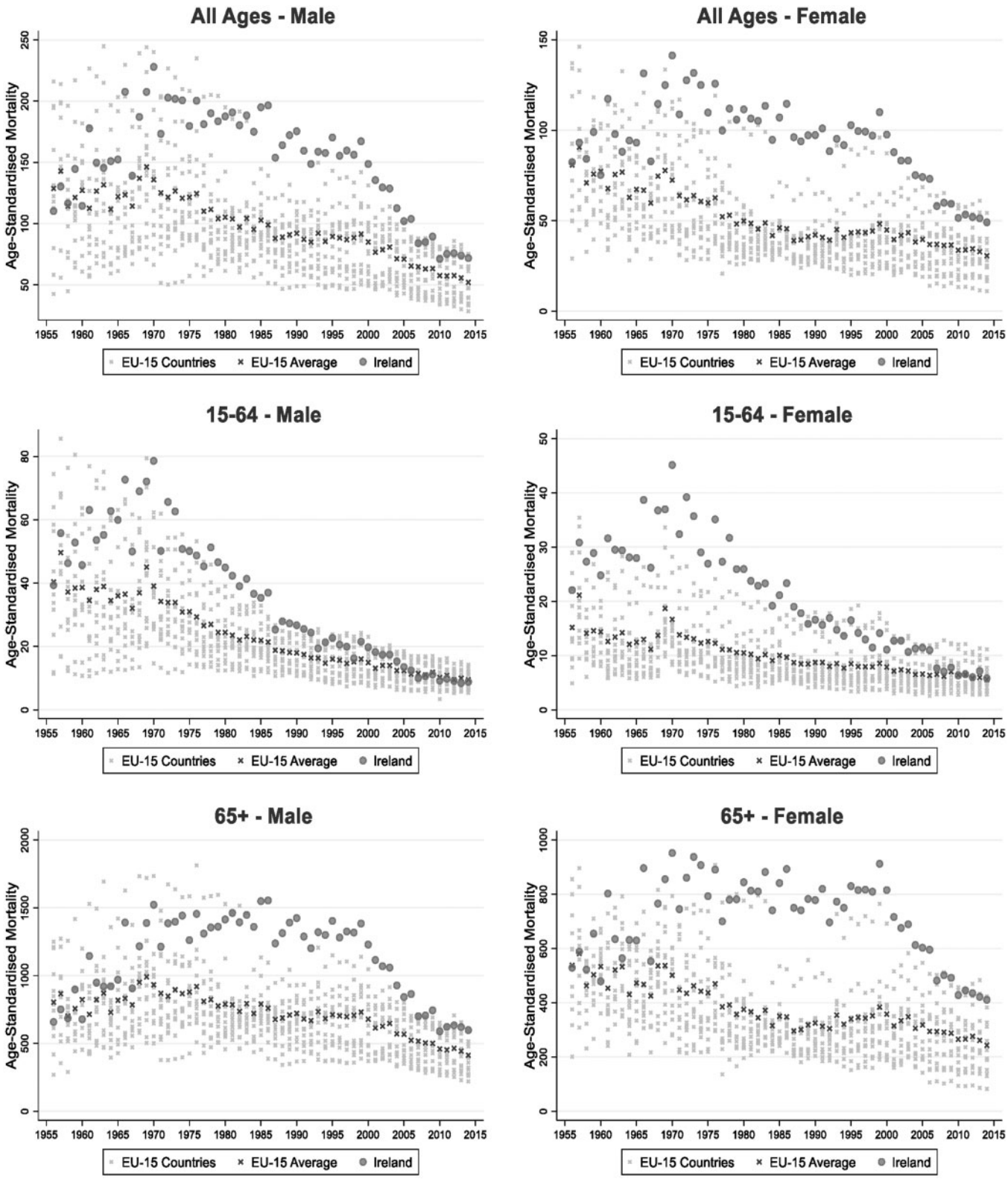

Figure 4 Age-standardized respiratory system mortality rates per 100 000 across sex and age categories: 1956–2014

deaths for males were a consequence of a reduction in cancer mortality.

The divergence and convergence in mortality between Ireland and the EU-15 differed across primary cause of death. In Ireland, and the EU-15 more generally, the largest improvements in mortality between 1956 and 2014 occurred for circulatory disease. EU-15 average circulatory disease ASMRs reduced by 70% and 76% for males and females, respectively, during the period of study, with a similar reduction observed in Ireland. However, in Ireland most of this reduction occurred in recent years with an acceleration in circulatory disease ASMR reductions occurring post-2000. The sharp downward trend in circulatory system disease mortality in Ireland began before the 2004 national smoking ban. However, there is evidence that the smoking ban did reduce smoking and exposure to second-hand smoke,[20] and in the 3 years following the ban, there was a 26% and 32% estimated reduction in ischaemic heart disease and stroke.[21] Other factors that may have contributed to the sharp reduction in circulatory disease mortality in Ireland are improved

lifestyle factors and drug prescribing. Previous research has found that between 1985 and 2000, coronary heart disease mortality rates in Ireland fell by 47% in those aged 25–84, with a just under half of the observed decreases attributed to declining smoking prevalence, lower cholesterol concentrations and lower blood pressure levels.[15,16] Evidence also points to improved cardiovascular drug prescribing in Ireland accounting for the acceleration in cardiovascular mortality reductions post-2000.[15]

The findings of this analysis on respiratory disease mortality are particularly stark. The analysis clearly shows a sharp divergence between Ireland and the EU-15 in earlier years. In many years, Irish respiratory disease ASMRs were double the EU-15 average. No definitive reason underpinning the high rates of mortality from respiratory disease has been provided in the literature. The Irish respiratory disease ASMR halved between 2000 and 2014, yet by 2014 had still not converged to the EU-15 average. Similar to circulatory disease mortality, while the trend in reduced respiratory disease mortality began prior to the 2004 smoking ban, there is evidence that the smoking ban reduced mortality from conditions of the respiratory system. In the 3 years following the ban, chronic obstructive pulmonary disease mortality reduced by an estimated 38%.[21] Our analysis also shows differences across age categories. While a convergence in respiratory disease ASMRs is clearly observed in the 15–64 age category, in the 65+ age category Ireland is still ranked as having the highest respiratory disease ASMR in the EU-15.

Cancer ASMRs saw relatively small reductions between 1956 and 2014, with the EU-15 average male and female cancer ASMRs reducing by 8% and 24%, respectively. A clear distinction in cancer ASMRs between Ireland and the EU-15 is observed across sexes. Male cancer ASMRs in Ireland were consistently lower than, or matched, the EU-15 average. Contrastingly, female cancer ASMRs in Ireland were much higher, and remain much higher, than the EU-15 average. This result is markedly clear for the 65+ age group where cancer ASMRs in Ireland were 25% higher than the EU-15 average in 2014. Previous research has argued that one reason cancer mortality in Ireland remains high relates to the slow implementation of cancer control programmes.[22,23]

The improvement in mortality in Ireland in recent years is dramatic in a European context, but also remarkable over the course of Irish history. The absolute life expectancy improvements that occurred in Ireland between 1996 and 2006 match the large reduction in mortality found in this study, and were amongst the highest absolute improvements observed since 1840.[24] Gains among the older population accounted for over half of the gains in life expectancy post-1986 and three-quarters of the overall gain post-1996.[24]

Socio-economic factors

Changes in mortality rates reflect a complex interplay of social, economic, institutional and health factors and it is difficult to untangle the role of each in determining changes in mortality in Ireland. Public health interventions, such as the smoking ban[20,21] and improved sanitation,[7] have aided the reduction in mortality for specific groups and causes of death. However, it is hard to overstate the dramatic changes to the Irish economic and social environment that occurred over recent decades that are likely to have affected health outcomes and mortality rates. The period between 1956 and 1990, when Irish ASMRs were amongst the worst in the EU-15, coincided with a period of poor economic performance,[25] with Gross National Product (GNP) per capita ~35% below the EU-15 average.[26] Ireland joining the European Economic Community in 1973 not only had a direct economic impact in terms of the opening up of the economy to international trade, attracting Foreign Direct Investment and providing access to the single market (all of which aided economic growth prospects), but it also had wider social and cultural effects.[27] Between 1990 and 2002, employment increased substantially and GNP per capita overtook the EU-15 average by 2002.[28] While Ireland has always spent a relatively large proportion of GNP/GDP on healthcare (e.g. in 1980 Ireland spent a similar proportion of GDP on healthcare as the USA[29]) as the economy improved so too did absolute spending on health. Significant increases in healthcare expenditure per capita have also been seen in recent years and Ireland has one of the highest health expenditures per capita in the world.[27,30] As living standards have risen, there has been a large increase in the demand for public and private healthcare services, and large public and private investments were also made in healthcare during this period.

Improved education rates may also underpin some of the improvements in both economic performance and mortality. Free second-level education introduced in 1967 increased access to education, while there was a larger increase in third-level education participation from the 1990s.[31] Irish third-level education rates are now amongst the highest in Europe.[32]

Limitations

There are a number of limitations in the analysis. First, missing mortality data exist for some countries in some years, however, where appropriate, linear interpolation and other sources have been used where data are missing. Second, changes in ICD codes took place at slightly different years across countries, though the cause of death categories we choose to focus upon mitigate most potential issues. While we postulate about what were the potential drivers of Ireland's initial poor mortality rates and recent mortality improvements, we could not explicitly measure the impact factors such as better economic conditions, high health expenditure and medical treatment improvements, have had on the Irish mortality story. Future work should endeavour to explain the causal link between these factors and mortality reductions further.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Key points

- Age-standardized mortality in Ireland was amongst the highest of all EU-15 countries during the latter half of the 20th century.
- Sharp reductions in age-standardized mortality occurred in Ireland from 2000, and all-cause mortality rates had converged to the EU-15 average by 2014.
- Mortality reductions in Ireland differed across sex, age and cause of death.
- Reductions in circulatory disease and respiratory disease at older ages accounted for the majority of the reduction in age-standardized mortality in Ireland.
- Policymakers should target improvements in respiratory disease and cancer mortality amongst females as mortality in Ireland remains high for these causes of death.

References

1 Mackenbach JP, Looman C. Life expectancy and national income in Europe, 1900-2008: an update of Preston's analysis. *Int J Epidemiol* 2013;42:1100–10.

2 Preston SH. The changing relation between mortality and level of economic development. *Popul Stud (Camb)* 1975;29:231–48.

3 Cutler D. *The Economics of Better Health: The Case of Cardiovascular Disease*. Cambridge, MA: Harvard University, 1999.

4 Cutler D, Meara E. Changes in the age distribution of mortality over the 20th Century. NBER Working Paper No 8556, 2001.

5 Cutler D, Miller G. The role of public health improvements in health advances: the twentieth-century United States. *Demography* 2005;42:1–22.

6 Mackenbach JP, Kulhánová I, Artnik B, et al. Changes in mortality inequalities over two decades: register based study of European countries. *BMJ* 2016;353:i1732.

7 Delaney L, McGovern M, Smith JP. From Angela's ashes to the Celtic tiger: early life conditions and adult health in Ireland. *J Health Econ* 2011;30:1–10.

8 Mackenbach JP. Convergence and divergence of life expectancy in Europe: a centennial view. *Eur J Epidemiol* 2013;28:229–40.

9 McGovern M. Progress and the lack of progress in addressing infant health and infant health inequalities in Ireland during the 20th century. *JSSISI* 2016;45:17–45.

10 Whelan SF. Recent trends in mortality and morbidity in Ireland. *JSSISI* 2008;37:135–63.

11 Hu Y, van Lenthe FJ, Mackenbach JP. Income inequality, life expectancy and cause-specific mortality in 43 European countries, 1987–2008: a fixed effects study. *Eur J Epidemiol* 2015;30:615–25.

12 Nolte E, McKee CM. Measuring the health of nations: updating an earlier analysis. *Health Aff (Millwood)* 2008;27:58–71.

13 Nolte E, McKee M. Variations in amenable mortality–trends in 16 high-income nations. *Health Policy* 2011;103:47–52.

14 Karanikolos M, Mackenbach JP, Nolte E, et al. Amenable mortality in the EU-has the crisis changed its course? *Eur J Public Health* 2018;28:864–9.

15 Layte R, O'Hara S, Bennett K. Explaining structural change in cardiovascular mortality in Ireland 1995-2005: a time series analysis. *Eur J Public Health* 2011;21:597–602.

16 Bennett K, Kabir Z, Unal B, et al. Explaining the recent decrease in coronary heart disease mortality rates in Ireland, 1985-2000. *J Epidemiol Community Health* 2006;60:322–7.

17 Geran L, Tully P, Wood P, et al. *Comparability of ICD-10 and ICD-9 for Mortality Statistics in Canada*. Statistics Canada, 2005.

18 Anderson RN, Minino AM, Hoyert DL, et al. Comparability of cause of death between ICD-9 and ICD-10: preliminary estimates. *Natl Vital Stat Rep* 2001;49:1–32.

19 Eurostat. *Revision of the European Standard Population: Report of the Eurostat's Task Force*. Luxembourg: European Commission, 2013.

20 Allwright S, Paul G, Greiner B, et al. Legislation for smoke-free workplaces and health of bar workers in Ireland: before and after study. *BMJ* 2005;331:1117.

21 Stallings-Smith S, Zeka A, Goodman P, et al. Reductions in cardiovascular, cerebrovascular, and respiratory mortality following the national Irish smoking ban: interrupted time-series analysis. *PLoS One* 2013;8:e62063.

22 Cao B, Bray F, Beltrán-Sánchez H, et al. Benchmarking life expectancy and cancer mortality: global comparison with cardiovascular disease 1981-2010. *BMJ* 2017;357:j2765.

23 Walsh B, Silles M, O'Neill C. The role of private medical insurance in socio-economic inequalities in cancer screening uptake in Ireland. *Health Econ* 2012;21:1250–6.

24 Walsh B. Life expectancy in Ireland since the 1870s. *Econ Soc Rev (Irel)* 2017;48:127–43.

25 Honohan P, Walsh B. Catching up with the leaders: the Irish hare. *Brookings Pap Econ Act* 2002;2002:1–78.

26 Kennedy KA. Reflections on the process of Irish economic growth symposium on economic growth in Ireland. Where has it come, where is it going? *JSSISI* 2001;30:123–58.

27 Keegan C, Connolly S, Wren M-A. Measuring healthcare expenditure: different methods, different results. *Ir J Med Sci* 2018;187:13–23.

28 Barry F. *Ireland as Productivity Bridge between the US and the EU*. Dublin: University College Dublin, 2006.

29 Chandra A, Skinner J. Technology growth and expenditure growth in health care. *J Econ Lit* 2012;50:645–80.

30 Turner B. Putting Ireland's health spending into perspective. *Lancet* 2018;391:833–4.

31 Fitzgerald J. The story of Ireland's failure—and belated success. In: B Nolan, CT Whelan, editors. *Bust to Boom? The Irish Experience of Growth and Inequality*. Dublin, Ireland: Institute of Public Administration, 2000.

32 O'Connell PJ, McCoy S, Clancy D. Who went to college? Socio-economic inequality in entry to higher education in the Republic of Ireland in 2004. *High Educ Q* 2006;60:312–32.