Trends in the Leading Causes of Death in Korea, 1983-2012

This study aimed to analyze trends in the 10 leading causes of death in Korea from 1983 to 2012. Death rates were derived from the Korean Statistics Information Service database and age-adjusted to the 2010 population. Joinpoint regression analysis was used to identify the years when statistically significant changes occurred in the trends. Between 1983 and 2012, the age-standardized death rate (ASR) from all causes decreased by 61.6% for men and 51.2% for women. ASRs from malignant neoplasms, diabetes mellitus, and transport accidents increased initially before decreasing. ASRs from hypertensive diseases, heart diseases, cerebrovascular diseases and diseases of the liver showed favorable trends (ASR % change: -94.4%, -53.8%, -76.0%, and -78.9% for men, and -77.1%, -36.5%, -67.8%, and -79.9% for women, respectively). ASRs from pneumonia decreased until the mid-1990s and thereafter increased. ASRs from intentional self-harm increased persistently since around 1990 (ASR % change: 122.0% for men and 217.4% for women). In conclusion, death rates from all causes in Korea decreased significantly in the last three decades except in the late 1990s. Despite the great strides made in the overall mortality, temporal trends varied widely by cause. Mortality trends for malignant neoplasms, diabetes mellitus, pneumonia and intentional self-harm were unfavorable.

Keywords: Mortality; Cause of Death; Trend; Joinpoint; Korea
tests, Bayesian information criterion (BIC), and modified BIC which was proposed to improve the performance of the traditional BIC method. As a result, the finally selected model is the most parsimonious model that best fits data (8). The number of joinpoints started from 0 and was increased to test if the addition of joinpoints improved the fitness of model significantly. No maximum number of joinpoints was set. The best-fitting model was estimated separately for men and women. The annual percent rate change (APC) was calculated for each segment of the best-fitting model using generalized linear models that assumed the Poisson distribution. The APC was tested to determine whether it was significantly different from the null hypothesis of no change (0%). The statistical power to determine if an APC is different from 0 is a function of the length of the interval, potentially rendering a short segment rising at a steep rate statistically insignificant. Significance tests were performed using a Monte Carlo permutation technique (two-sided P < 0.05). The Joinpoint Regression Program version 4.1.4 (US National Cancer Institute, Bethesda, MD, USA) was used for the statistical analysis. Approval from the institutional review board was not required for this study as it analyzed the anonymised data made publicly available.

RESULTS

Table 1 summarizes the trends in overall and cause-specific death rates for the 10 leading causes of death of Korean men and women from 1983 to 2012. ASR from all causes combined was 638.8 deaths per 100,000 men and 587.5 per 100,000 women in 2012, representing decreases of 61.6% and 51.2%, respectively, over the 30-yr study period. Only 2 joinpoints were identified for the overall death rates. ASR from all causes combined has steadily and significantly declined in both genders except for the period of 1998-2001.

Temporal trends in ASR for the 10 leading causes of death varied by cause of death and by gender (Tables 2, 3, and Fig. 1). ASRs from malignant neoplasms in both genders increased until 1994 and thereafter declined except for the period of 1998-2002. ASRs from diabetes mellitus increased up to 2003 and 2002 for men and women, respectively, but thereafter declined at a significant pace.

Table 1. Crude and age-standardized death rates for the 10 leading causes of death in Korean men and women, 1983-2012

| Causes of death                        | 1983                  | 2012                  | ASR % Change | 1983                  | 2012                  | ASR % Change |
|----------------------------------------|-----------------------|-----------------------|--------------|-----------------------|-----------------------|--------------|
|                                        | Deaths*               | CDR*                  | ASR*         | Deaths*               | CDR*                  | ASR*         |
| All causes                             | 148,101               | 735.8                 | 1,665.6      | 147,372               | 588.6                 | 638.8        | -61.6        | 114,894     | 480.1      | 587.5       | -51.2       |
| Malignant neoplasms                    | 17,789                | 88.4                  | 187.7        | 46,462                | 185.6                 | 170.7        | -9.1         | 10,998      | 55.6       | 102.8       | -1.1        |
| Diabetes mellitus                      | 1,050                 | 5.2                   | 11.1         | 5,849                 | 23.4                   | 21.3         | 91.8         | 757         | 3.8        | 7.5         | 20.8        |
| Hypertensive diseases                  | 11,561                | 57.4                  | 138.5        | 1,620                 | 6.5                    | 7.7          | -94.4        | 7,313       | 37.0       | 84.0        | 19.2        |
| Heart diseases                         | 10,565                | 52.5                  | 112.3        | 13,058                | 52.1                   | 51.9         | -53.8        | 8,435       | 42.6       | 91.7        | 176.0       |
| Cerebrovascular diseases               | 14,749                | 73.3                  | 186.7        | 12,380                | 49.4                   | 44.8         | -76.0        | 12,173      | 61.5       | 149.4       | 48.2        |
| Pneumonia                              | 2,338                 | 11.6                  | 15.7         | 5,203                 | 20.8                   | 18.4         | -16.9        | 2,193       | 10.6       | 12.4        | 19.9        |
| Chronic lower respiratory diseases     | 2,262                 | 11.2                  | 32.3         | 4,844                 | 19.3                   | 17.1         | -47.0        | 1,979       | 10.0       | 26.0        | 10.5        |
| Diseases of the liver                  | 9,770                 | 48.5                  | 95.9         | 5,364                 | 21.4                   | 20.2         | -78.9        | 2,793       | 14.1       | 26.6        | 5.4         |
| Transport accidents                    | 3,524                 | 16.2                  | 21.3         | 4,785                 | 19.1                   | 18.4         | -13.6        | 1,067       | 5.4        | 6.6         | -0.6        |
| Intentional self-harm                  | 2,554                 | 12.7                  | 16.7         | 9,622                 | 38.4                   | 37.1         | 122.2        | 917         | 4.6        | 5.6         | 217.4       |

*Number of deaths; CDR, crude death rates (per 100,000); ASR, age-standardized death rates adjusted to the 2010 Korean standard population (per 100,000); †The difference between the 2012 and 1983 rates expressed as percentage of the 1983 rate.

Table 2. Trends in age-standardized death rates of the 10 leading causes of death in Korean men according to joinpoint analysis, 1983-2012

| Causes of death                        | Trend 1 1983-1998 | Trend 2 1993-1999 | Trend 3 1998-2001 | Trend 4 1994-1998 | Trend 5 1995-2000 | Trend 6 2000-2012 |
|----------------------------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|
| All causes                             | -2.93*            | -3.75*            | -3.92*            | -2.78*            | -3.60*            | -3.06*            |
| Malignant neoplasms                    | -0.55*            | 2.00*             | 1.54*             | 1.94*             | 1.54*             | 1.49*             |
| Diabetes mellitus                      | 0.50*             | 2.38*             | 1.54*             | 1.98*             | 1.54*             | 1.49*             |
| Hypertensive diseases                  | -10.71*           | -8.59*            | -13.31*           | -5.33*            | -30.59*           | -6.50*            |
| Heart diseases                         | -2.92*            | -6.56*            | -6.56*            | -5.33*            | -10.00*           | -6.50*            |
| Cerebrovascular diseases               | -4.33*            | -8.56*            | -8.56*            | -5.33*            | -15.00*           | -6.50*            |
| Pneumonia                              | 1.11*             | -4.92*            | -4.92*            | -5.33*            | -6.49*            | -6.50*            |
| Chronic lower respiratory diseases     | -1.54*            | -5.93*            | -5.93*            | -4.92*            | -6.49*            | -6.50*            |
| Diseases of the liver                  | -5.38*            | -3.18*            | -3.18*            | -2.22*            | -3.18*            | -2.22*            |
| Transport accidents                    | -3.10*            | 1.02*             | 1.02*             | 1.86*             | 1.02*             | 1.86*             |
| Intentional self-harm                  | 4.39*             | -4.84*            | -4.84*            | 12.10*            | 12.10*            | 12.10*            |

*APC, annual percent rate change of age-standardized death rate; †The annual percent rate change is significantly different from 0 (two-sided P < 0.05).
Over the last three decades, crude death rates from all causes in Korea declined. The favorable trends in mortality from all causes became more pronounced when ASRs were examined and were shown to be consistent as evidenced by the number of joinpoints identified (n = 2). The consistently favorable trends in the overall death rate may be attributable to a number of factors including advances in diagnostic and medical technologies, improved access to care due to expansion of health insurance coverage, and the rapidly progressed economy that the country witnessed during the study period. By contrast, the increasing, albeit insignificant, trend in the overall death rate in 1998-2001 may have been caused by the 1997 Asian financial crisis that hit Korea hard.

The generally consistent, favorable trends observed in the overall death rate were not replicated in some cause-specific death rates. Malignant neoplasms were the first leading cause by a narrow margin (1%) for men and the second leading cause of death for women in 1983. ASRs from malignant neoplasms increased since the mid-1980s with increase of cancer incidence in Japan (3) and Italy (8) in the corresponding period (9). Decrease of cancer mortality along with increase of cancer incidence in Japan (3) and Italy (8) in the 1990s was mostly attributed to a number of factors including early detection and treatment, and various public health strategies. The recent decline in cancer mortality in Korea may be explained by decreases in stomach, liver and uterine cancer mortality, due at least in part to the nationwide cancer screening program introduced in 1999 and subsequently expanded (10).

ASRs from diabetes mellitus increased since the mid-1980s up to the early 2000s, showing a similar pattern to mortality in the United States (5, 11). Despite the brief decline in 2002-2003, ASRs from diabetes mellitus more than doubled between 1983 and 2012. Consequently, diabetes mellitus was the second highest increasing cause of death among all causes of death examined in this study, surpassed only by intentional self-harm. The
Fig. 1. Trends in age-standardized death rates for the 10 leading causes of death in Korea, 1983-2012. Rates are age-adjusted to the 2010 Korean standard population.
A steep rise in diabetes mortality may be due to the reported six- to seven-fold increase in the prevalence of diabetes in Korea over the last four decades (12).

ASRs from hypertensive diseases, heart diseases and cerebrovascular diseases decreased significantly during the study period. Especially, ASRs from heart diseases in Korea had been steadily decreasing until recently, except for a spike in women in the mid-1990s. Similarly, a steady and marked decline in death rates from heart diseases was also observed in the United States since 1970 (5, 13), in tandem with continuously improved control of hypertension, a major risk factor for cardiovascular disease (14), and due in part to the use of effective medical and surgical treatments (13). Markedly declining death rates from coronary heart diseases since the 1970s were also observed in Latin America and Europe (14-16). Death rates from cerebrovascular diseases have also decreased consistently and markedly in many countries around the world since the 1960s (14, 16, 17), which was attributed to a decrease in the intake of dietary salt and saturated fat (17).

The most consistently downward trend of death rate was observed in diseases of the liver, resulting in the greatest reduction in mortality among the leading causes of death examined. The favorable trend in mortality from liver diseases in Korea may be ascribed to the declining prevalence of hepatitis B surface antigen (HBsAg) from the 1980s due in no small part to increased hepatitis B vaccination rates (18). Mortality from cirrhosis has shown favorable trends around the world since 1980, due in part to reductions in alcohol consumption and hepatitis B and C virus infections (19, 20). In the United States, however, the favorable trends in death rates from hepatitis B and C virus infections did not continue in the 1990s, although death rates from alcohol-related chronic liver disease declined (21-23). A follow-up analysis of closely investigating the trends in mortality from diseases of the liver by specific cause is needed.

While infectious disease mortality, especially for pneumonia and influenza, was known to fluctuate from year to year, pneumonia remained among the leading causes of illness and death even in the industrialized countries (24, 25). In our analysis, death rates from pneumonia decreased until the mid-1990s and thereafter increased, resulting in overall increases of 16.9% and 44.2% for men and women, respectively. Pneumonia mortality appeared to increase with economic crisis (26). Older people have a higher risk of death from infectious diseases including pneumonia than younger people do (25). The resurgence of pneumonia in Korea appears to be attributable to the fact that Korea has the rapidest aging population in the world (27), which distinguishes the country from other countries where ASRs of pneumonia declined in recent decades (28). The finding warrants reinforcement of pneumonia surveillance and control programs in Korea, which could include increasing pneumococcal and influenza vaccination rates as well as a more judicious use of antibiotics (28).

ASRs from chronic lower respiratory diseases declined by around 50% from 1983 to 2012 despite the periodic fluctuations. In the United States, mortality from the diseases has decreased over the last decade although they remained the third leading cause of death in 2010 (29). Moreover, the worldwide death rates from chronic respiratory diseases were projected to decline up to 2020 (30). Chronic lower respiratory diseases are a set of various diseases affecting the lower respiratory tract including asthma, chronic bronchitis, and chronic obstructive pulmonary disease (COPD), suggesting that further research is needed to illuminate the trend. For example, the increasing death rates from COPD in the earlier decades appeared to have stabilized in the 2000s in the United States (5). Death rates from COPD also tended to decline around the world but not in Korea (31, 32).

ASRs from transport accidents in Korea grew at an accelerated pace until the late 1980s and continued to grow, albeit at a slower rate, in the mid-1990s when the rates started to decline. The changing trend may reflect the nation’s economic development over the study period. The relationship between economy and transport mortality was reported to be non-linear such that economic development initially would contribute to an increasing number of motor vehicles resulting in more traffic accidents, but further investment in transport infrastructure would decrease deaths from transport accidents (33).

Perhaps, the most alarming mortality trend was observed for intentional self-harm. The rates have increased dramatically and persistently for men since 1991. In fact, the overall percentage increase in the death rates from intentional self-harm for 30 yr was the highest among all the leading causes of death examined. Consequently, suicide mortality now surpasses the death rates from diabetes, pneumonia and liver disease, highlighting urgency with which increasing suicide mortality should be addressed.

Suicide rates were reported to increase in times of economic crisis in respective countries (26, 34). The impact of changes in economy, employment and other socioeconomic factors on suicide rates may have been greater among men in recent decades (35). The 2008 global economic crisis increased suicide rates disproportionately more among men in many countries (36). In the present study, however, from the ASR % change for intentional self-harm over 30 yr was shown to be higher for women while their ASRs stayed consistently lower throughout the period, compared with men. The finding might be a sign that women who had the comparatively low suicide mortality three decades earlier were catching up with men. Similarly, there were substantial differences between genders in death rates from malignant neoplasms, diseases of the liver, and transport accidents, but the disparities tended to narrow in recent years. In other countries, diverging temporal trends between genders were reported for stroke and COPD mortality (37, 38).
To our knowledge, this study is the first to statistically test the long-term trends in the leading causes of death in Korea. Nonetheless, the findings of this study should be interpreted with caution in light of the following limitations. First, the data source used in this study may be subject to potential misclassification of causes of death in official death certificates. A previous study noted that the registered causes of death in Korea may be inaccurate: agreement rates between death certificates and medical charts were 80.4% in malignant neoplasms and 76.6% in circulatory diseases in a regional district in 1998 (39). Second, the accuracy of causes of death on death certificates may have evolved over time due to advances in diagnostic techniques, potentially rendering some mortality data incomparable between different time periods. Third, the ICD-9 coding scheme in KOSIS data was replaced with the ICD-10 in 1995, which may have influenced the trends. Previously, it was suggested that changes in temporal pattern of mortality might reflect changes in documentation and diagnostic coding rather than real improvement in survival (40).

In conclusion, death rates from all causes in Korea decreased significantly in both genders in the last three decades except for a period following the economic crisis in the late 1990s. Despite the great strides made in the overall mortality, temporal trends in cause-specific mortality varied widely by cause. Whereas hypertensive diseases, heart diseases, cerebrovascular diseases and diseases of the liver showed favorable trends, malignant neoplasms, diabetes mellitus, pneumonia and intentional self-harm showed unfavorable trends. The persistently high and increasing causes of death should be addressed with the highest priority, and disease surveillance and control systems targeting the diseases should be implemented.

DISCLOSURE

The authors have no conflicts of interest to disclose.

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