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The life expectancy gap between North and South Korea from 1993 to 2008

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Background: Comparative research on health outcomes in North and South Korea offers a unique opportunity to explore political and social determinants of health. We examined the age- and cause-specific contributions to the life expectancy (LE) gap between the two Koreas. **Methods:** We calculated the LE at birth in 1993 and 2008 among North and South Koreans, and cause-specific contributions to the LE discrepancy between the two Koreas in 2008. The cause-specific mortality data from South Korea were used as proxies for the cause-specific mortality data in North Korea in 2008. **Results:** The LE gap between the two Koreas was approximately 1 year in 1993, but grew to approximately 10 years in 2008. This discrepancy was attributable to increased gaps in mortality among children younger than 1 year and adults 55 years of age or older. The major causes of the increased LE gap were circulatory diseases, digestive diseases, infant mortality, external causes, cancers and infectious diseases. **Conclusions:** This study underscores the urgency of South Korean and international humanitarian aid programs to reduce the mortality rate of the North Korean people.

Introduction

After the German reunification, the two Koreas, North (the Democratic People's Republic of Korea) and South (the Republic of Korea), became the only country divided for opposing political ideologies. Despite the different social systems (socialist regime vs. free market economy) during the past 6-decade armistice since the Korean War (1950–53), the two Koreas share same language, culture and ethnic back grounds.[1] The regime competition between the two Koreas has occurred in educational and social security systems in addition to the very high levels of military forces. Before the 1990s, according to data from the World Bank (figure 1), the estimated life expectancy (LE) was similar between North and South Korea. However, the LE gap between the North and the South has widened since the early 1990s in both men and women. Between 1991 and 1998, the LE in North Korea decreased by 5.6 years in men (to a low of 60.3 years) and 4.7 years in women (to a low of 68.3 years). The magnitude of LE decrease is remarkable considering that the mortality crisis in Russia, followed by the collapse of the Soviet Union in 1991, had resulted in LE decreases by 6.2 years in men and 3.4 years in women.[2,3] The recent crisis in Syria was associated with LE declines by 5–6 years.[4] The public health deterioration, including the LE reversal, during the 1990s in North Korea has been explained as the result of the economic decline after the collapse of the Soviet Union in 1991 and the massive famine in North Korea in the mid-1990s.[5–7]

Comparative research on the LE gap between the two Koreas offers a unique opportunity to assess political and social determinants of health.[1] The health status of North Koreans is not well-quantified due to the scarcity of primary data. Fortunately, two censuses of the population were conducted in North Korea in 1993 and 2008 with assistance from the United Nations Population Fund. These data provide a valuable opportunity for examining LE in North Korea. The age- and cause-specific contributions to the LE gap between the two Koreas represent crucial information for elucidating the factors contributing to the LE gap between the two Koreas.

In this study, we explored LE discrepancies between North and South Korea at two points in time (in 1993 and 2008) using published population and mortality data from the two Koreas and estimated the age- and cause-specific contributions to the LE disparity in 2008.

Methods

Study design and participants

In this study, we explored the age- and cause-specific contributions to the LE gap between the two Koreas. Age-specific contributions to the LE disparity, which can be directly calculated from the published data, may provide information on the relative importance of childhood versus adulthood causes of death. Although some reports provide causes of death information in North Korea,[8,9] however, gender- and age-specific information on causes of death collected in North Korea are not available. Therefore, we assumed that the structure of North Korean causes of death would be more similar to the corresponding South Korean data than to data from any other countries and would follow the trajectories of mortality that South Korea has experienced. We hypothesized that, if the cause-specific mortality rates were analogous, the age-specific mortality rates would be also similar between the two Koreas. We attempted to select the corresponding time points in the trajectory of South Korean mortality rates by pinpointing the calendar years when the LE difference and the absolute age-specific contributions to the LE difference between the two Koreas were minimized. See Supplementary data for more details and for a discussion of the validation with the other available data. This study only used publicly accessible secondary data without any personal identifiers. An exemption of the Institutional Review Board approval was granted by the Seoul National University Hospital Institutional Review Board (IRB number E-1411-001-620).

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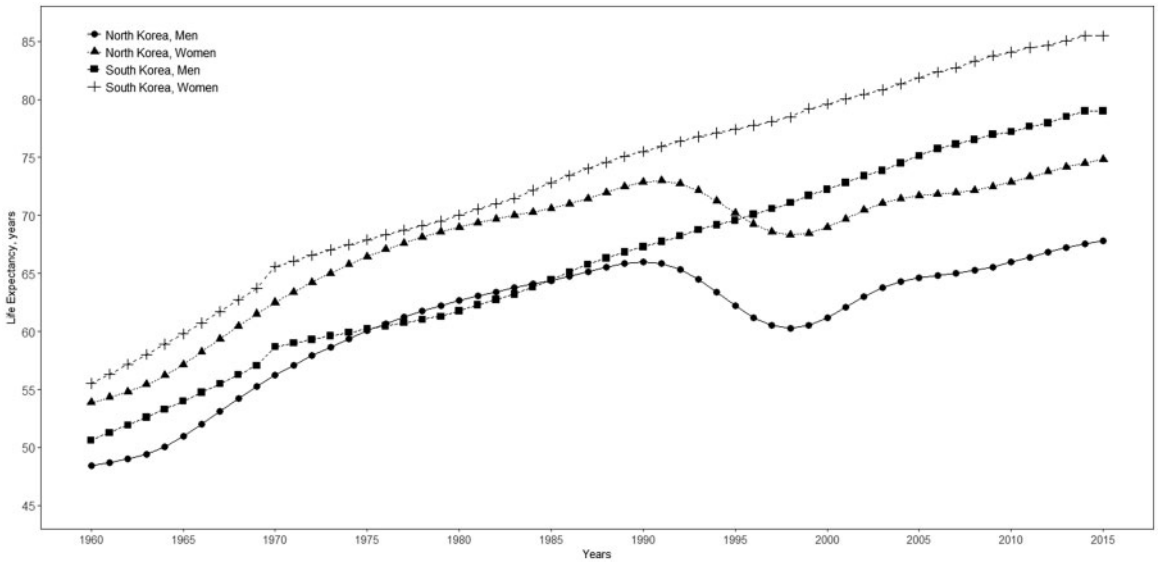

Figure 1 Estimated life expectancy in North and South Korea by gender from 1960 to 2015 (Data from World Development Indicators, The World Bank, Version: December 2014; Sources for calculating life expectancy were (1) United Nations Population Division: World Population Prospects; (2) United Nations Statistical Division: Population and Vital Statistics Report (various years); (3) Census reports and other statistical publications from national statistical offices; (4) Eurostat: Demographic Statistics; (5) Secretariat of the Pacific Community: Statistics and Demography Programme and (6) U.S. Census Bureau: International Database)

Data from North Korea

We used the 1993 and 2008 census data from North Korea, which are available from the Korean Statistical Information Service (http://kosis.kr/bukhan/index.jsp) of Statistics Korea, the official statistical department of South Korea. Information on the number of deaths was available from the two censuses, derived from questions about the death(s) of family members in the previous year. A similar approach to determine the numbers of deaths was used in a prior study on North Korean mortality.[10] The population size and number of deaths according to gender and 5-year age groups (0 years, 1–4 years, 5–9 years, …, 75–79 years, 80+ years) were obtained for 1993 and 2008. The 1993 census, which was the first population census in North Korea, was conducted with assistance from the United Nations Population Fund between 3 and 15 January 1994, with a reference date of 31 December 1993.[11,12] The 2008 census, which was the second population census in North Korea, was conducted by the Central Bureau of Statistics of North Korea with assistance from the United Nations Population Fund and the South Korean government between 1 and 15 October 2008, with a reference date of 1 October 2008.[11,12]

Data from South Korea

We used South Korean registered population and mortality data for the years 1983–90, 1993 and 2008, which are also available from the Korean Statistical Information Service (http://kosis.kr/) of Statistics Korea. The population data were based on the resident registration system of the South Korean government. The registered population data included the quantitative breakdown of the population by gender and 1-year age groups. Mortality data from the death certificate registry included the number of deaths by cause of death, gender and 5-year age group. Deaths must be reported to Statistics Korea by law in South Korea, and data on causes of death have been available since 1983. Causes of death were coded according to the International Classification of Diseases, 10th Revision (ICD-10). Causes of death initially coded in ICD-9 were converted by Statistics Korea using the conversion table published by the World Health Organization.[13] We grouped the infantile death as a separate category for the disease-group specific contribution to the LE gap between the two Koreas (table 2), considering that the registered numbers of infant deaths in South Korea are known to be incomplete in 1980s.[14]

Statistical analysis

We calculated the LE at birth for men and women in 1993 and 2008 among North and South Koreans, constructing life tables using the 5-year probabilities of death. We employed Arriaga's LE decomposition method to estimate age-specific contributions to the LE discrepancy.[15] The results of decomposition are not sensitive to the LE decomposition method.[16] We also calculated cause-specific contributions to the LE difference between North and South Korea in 2008. These cause-specific contributions were estimated using prior South Korean cause-specific mortality data as proxies for North Korean data (see Supplementary data for more detailed methods and for a discussion of the validation with the other available data). We categorized the causes of death into 18 groups (see table 2 for the categorization of causes of death), while infant deaths (i.e. deaths of children <1 year of age) were categorized separately.

Results

Table 1 shows that the North Korean LE was close to the South Korean LE in 1993 (with a gap of 0.68 years in men and 1.24 years in women), whereas the LE gap increased to 11.14 years among men and 9.90 years among women in 2008. The increase in the LE gap between North and South Korea reflects the fact that the LE in South Korea rose by 6.35 years over this 15-year period, while the LE in North Korea dropped by 3.48 years (Supplementary table S2). The increased gap in the LE between the two Koreas during the 15 years (10.46 years in men and 8.66 years in women) was attributable to the increased difference in mortality rates among children younger than 1 year of age (9.1% in males and 10.7% in females) and among adults aged 55 years or older (42.3% in men and 53.2% in women). In addition, men 20–24 years of age contributed 8.1% to the increased LE difference between the two Koreas (table 1).

Table 2 shows the cause-specific contributions to the LE gap between North and South Korea in 2008 (South Korea respect to North Korea). In men, circulatory diseases, ill-defined causes,

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Table 1 Age-specific contributions (years and percentage) to the life expectancy gap between North and South Korea (South Korea respect to North Korea) among men and women in 1993 and 2008

	1993 (South − North)		2008 (South − North)			
Age group	**Year (A)**	**% of A**	**Year (B)**	**% of B**	**B − A**	**% of (B − A)**
Men						
0	0.33	48.4	1.28	11.5	0.95	9.1
1–4	0.61	89.8	0.48	4.3	−0.13	−1.2
5–9	0.05	6.7	0.29	2.6	0.25	2.4
10–14	−0.01	−1.4	0.22	1.9	0.23	2.2
15–19	−0.15	−21.5	0.32	2.9	0.47	4.5
20–24	−0.11	−15.7	0.74	6.7	0.85	8.1
25–29	−0.08	−12.3	0.45	4.0	0.53	5.1
30–34	−0.14	−20.6	0.42	3.8	0.56	5.4
35–39	−0.25	−37.2	0.35	3.2	0.61	5.8
40–44	−0.31	−45.6	0.26	2.3	0.57	5.4
45–49	−0.35	−52.2	0.19	1.7	0.54	5.2
50–54	−0.41	−60.2	0.21	1.9	0.62	5.9
55–59	−0.12	−17.0	0.75	6.8	0.87	8.3
60–64	0.42	61.4	1.49	13.4	1.07	10.3
65–69	0.44	64.7	1.55	13.9	1.11	10.6
70–74	0.41	59.7	1.05	9.4	0.65	6.2
75–79	0.27	39.8	0.77	6.9	0.50	4.8
80+	0.09	13.2	0.31	2.8	0.22	2.1
Total	0.68	100.0	11.14	100.0	10.46	100.0
Women						
0	0.30	24.4	1.23	12.4	0.93	10.7
1–4	0.70	56.9	0.48	4.9	−0.22	−2.6
5–9	0.03	2.1	0.25	2.5	0.22	2.5
10–14	−0.01	−0.6	0.22	2.2	0.23	2.6
15–19	−0.01	−0.6	0.28	2.9	0.29	3.4
20–24	0.01	1.0	0.30	3.1	0.29	3.4
25–29	0.01	0.8	0.30	3.0	0.29	3.3
30–34	−0.03	−2.8	0.30	3.0	0.33	3.8
35–39	−0.09	−7.1	0.27	2.7	0.36	4.1
40–44	−0.11	−8.7	0.27	2.7	0.38	4.3
45–49	−0.14	−11.5	0.30	3.1	0.44	5.1
50–54	−0.18	−14.6	0.33	3.4	0.51	5.9
55–59	−0.13	−10.4	0.69	6.9	0.82	9.4
60–64	0.03	2.1	1.09	11.0	1.07	12.3
65–69	0.10	7.7	0.95	9.6	0.86	9.9
70–74	0.22	17.4	0.88	8.9	0.67	7.7
75–79	0.39	31.2	0.98	9.9	0.59	6.8
80+	0.16	12.9	0.78	7.9	0.62	7.1
Total	1.24	100.0	9.90	100.0	8.66	100.0

Table 2 Disease group-specific contributions (years) to the life expectancy gap between North and South Korea (South Korea respect to North Korea) by gender in 2008

Cause of death	**Men**	**Women**
Infant mortality	1.15	1.33
Infectious diseases (A00–B99)	0.56	0.40
Cancers (C00–D48)	0.61	0.28
Diseases of the blood and blood-forming organs and certain disordersinvolving the immune mechanism (D50–D89)	0.00	0.01
Endocrine, nutritional and metabolic diseases (E00–E88)	−0.02	−0.07
Mental and behavioural disorders (F00–F99)	0.03	−0.03
Diseases of the nervous system (G00–G99)	0.05	0.03
Diseases of the eye and adnexa (H00–H59)	0.00	0.00
Diseases of the ear and mastoid process (H60–H95)	0.00	0.00
Diseases of the circulatory system (I00–I99)	3.38	3.02
Diseases of the respiratory system (J00–J99)	0.32	0.38
Diseases of the digestive system (K00–K93)	1.34	0.61
Diseases of the skin and subcutaneous tissue (L00–L99)	0.00	0.00
Diseases of the musculoskeletal system and connective tissue (M00–M99)	0.02	0.00
Diseases of the genitourinary system (N00–N99)	0.04	0.03
Pregnancy, childbirth and the puerperium (O00–O99)	0.00	0.02
Congenital malformations, deformationsand chromosomal abnormalities (Q00–Q99)	0.02	0.01
Ill-defined causes (R00–R99)	3.25	3.65
External causes (V01–Y89)	0.93	0.16
Total	11.70	9.83

Notes: The cause-specific mortality data from South Korea (1985 mortality data for men and 1984 mortality data for women) were used as proxies for the cause-specific mortality data in North Korea in 2008. Thus, the total life expectancy gaps are different from those presented in table1.

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digestive diseases, infant deaths and external causes were major causes, contributing to 85.9% (10.05 years) of the LE gap. In contrast, in women, ill-defined causes, circulatory diseases, infant deaths, digestive diseases and infectious diseases accounted for 91.7% (9.01 years) of the LE difference (table 2).

As shown in figure 2, diseases of the circulatory system and ill-defined causes contributed considerably to the LE differences among men and women aged 50 or over, while cancer contributed negatively to the differences among men and women aged 65 or over. External causes (intentional and unintentional injuries) showed positive contributions in boys and girls aged 1–9 years and in younger men (20–34 years of age), while those causes negatively contributed to the LE gap in men 60 years of age or over and women 70 years of age or older (figure 2).

Discussion

In this study, we explored the age- and cause-specific contributions to the LE difference to provide explanations of the tremendous difference in LE between North and South Korea. During the 15-year period between 1993 and 2008, the LE gap between the two Koreas substantially increased. The LE in South Korea rose by 6.4 years, whereas the LE in North Korea decreased by 3.5 years. The recent Socio-Economic, Demographic and Health Survey in 2014 from North Korea also showed the LE still behind the LE in 1993.[17] Based on the Global Burden of Disease Study, the LE in South Korean men and women ranked the 32th and 16th in 2013, respectively, among 188 countries in the world, while North Korean men and women ranked the 108th and 107th.[18] The LE gap between two Koreas was approximately 1 year in 1993, but it became about 11 years in men and 10 years in women in 2008. Abrupt declines in LE during and after armed conflicts or natural disasters have been noticed.[19,20] However, a sustained divergence of LE by about 10 years has been rarely recorded. Considering that the maximum LE gap between East and West Germany before reunification was about 3 years,[21] this would be one of the largest divergences in LE recorded in the world. When we explored age- and cause-specific contributions to the increased gap, we found that the gap was largely attributable to increased discrepancies in mortality rates among children younger than 1 year and adults aged 55 years or older. The major causes of the increased LE gap were circulatory diseases, digestive diseases, infant mortality, external causes (for men), cancers (for men) and infectious diseases. Between these two time points, both North and South Korea experienced social and economic changes, which led to opposite changes in the mortality rate between the two countries, although North and South Korea had similar LEs prior to the 1990s.[22] Several social and economic factors may have affected the mortality differentials between the two Koreas. A severe and prolonged food shortage in North Korea during the intercensal period was one important factor, especially for childhood deaths. After the collapse of the Soviet Union in 1991, North Korea lost its major trading partner and source of assistance, and subsequently experienced an economic decline and an insufficient supply of grain.[23,24] Natural disasters made the economic situation worse. Floods in 1995 and 1996 and drought in 1997 led to a tremendous famine in North Korea.[24] The consequent reduced food rations could not provide a sufficient amount of the minimum daily caloric requirement, and almost two thirds of children were malnourished in the late 1990s.[24–26] The famine in the mid-1990s in North Korea has been estimated to have resulted in between 250, 000 and 1.1 million excess deaths.[24,27,28] International food assistance started in 1995 at the request of North Korea and has continued since, but North Korea has nonetheless suffered chronic food shortages during the last two decades.[29] In addition, the flooding in the mid-1990s damaged the health infrastructure, and the ongoing economic difficulties and electric power shortages hindered the provision of sufficient health care services and pharmaceutical supplies,[24,25] which may have contributed to increased infant mortality.

Chronic malnutrition may be associated with increased mortality, especially among those who experienced starvation during their childhood and childbearing periods. In the North Korean census data, we found that the mortality rate in 2008 among men and women 10–39 years of age (who experienced their childhood and adolescence in the 1990s) and in women 40–49 years of age (who were of childbearing age in the 1990s) were more than twice as high as the corresponding mortality rates in 1993 (Supplementary table S3). We also found a relatively greater age-specific contribution among men 20–24 years of age to the LE gap between the two Koreas compared with women in the same age group (table 1). This rise in the age-specific contribution among men 20–24 years of age was associated with excess mortality due to external causes (figure 2A), which may be attributable to increased mortality rates from injuries among young men in the North Korean army.

The analysis of cause-specific contributions to the LE gap showed that circulatory diseases were the major contributor in both men and women. A prior South Korean study showed that haemorrhagic stroke, rather than ischemic stroke, was the main cause of stroke mortality in the 1980s.[30] Hypertension has been more closely associated with haemorrhagic stroke than ischemic stroke.[31] A prior comparative study using KNHANES data from South Korea and North Korean WHO STEPS data showed that the systolic blood pressure was 8.7 mmHg and 11.7 mmHg greater among representative North Korean men and women 25–64 years of age, respectively, compared with their South Korean counterparts.[1] This remarkable difference in systolic blood pressure may have played a role in the significant contribution of circulatory disease to the LE difference between the two Koreas, and may be due to lower levels of hypertension treatment and greater levels of salt intake in North Korea.

The results regarding cause-specific contributions to the LE gap (table 2) also indicate that digestive diseases contributed to the LE gap by 1.34 years in men and 0.61 years in women, respectively. Data from North Korean defectors have shown a relatively greater prevalence of hepatitis B than residents in South Korea.[32–34] A prior study reported that the prevalence of hepatitis B was approximately 7% in a North Korean city.[35] The prevalence of hepatitis B and the associated mortality from liver cirrhosis have substantially declined in South Korea in the past three decades due to vaccination programs.[36] The WHO STEPS data from North Korea showed a gendered pattern of alcohol consumption.[1] Increased levels of viral hepatitis B infection and gendered patterns of alcohol consumption in North Korea may have resulted in the meaningful contribution of liver disease to the LE gap and the gender difference in the contributions of digestive diseases.

This study has limitations regarding the data used. First, our analysis of cause-specific contributions to the LE gap between the two Koreas was based on the assumption that cause-specific mortality patterns in North Korea would follow the trajectory of South Korea. Indirect estimation methods of mortality trends may be the only options for nations such as North Korea, which does not provide any detailed cause-of-death information based on primary data.[10] Hence, the North Korean cause-specific mortality structure in 2008 was assumed to be similar to the South Korean cause-specific mortality rates in the mid-1980s when the LE difference between the two Koreas was minimal and the age-specific mortality patterns between the two Koreas were similar. However, it is unclear if South Korea in the mid-1980s was similar to North Korea in 2008 in terms of cause-specific mortality. This assumption may be questioned in light of the fact that two Koreas have experienced different social and economic systems during the past several decades. For example, the free market economy may be different from the socialist regime regarding the production of and access to health-related commodities (e.g. tobacco, alcohol and processed food products). However, the levels of exposure to tobacco and alcohol, overweight and obesity, and high blood

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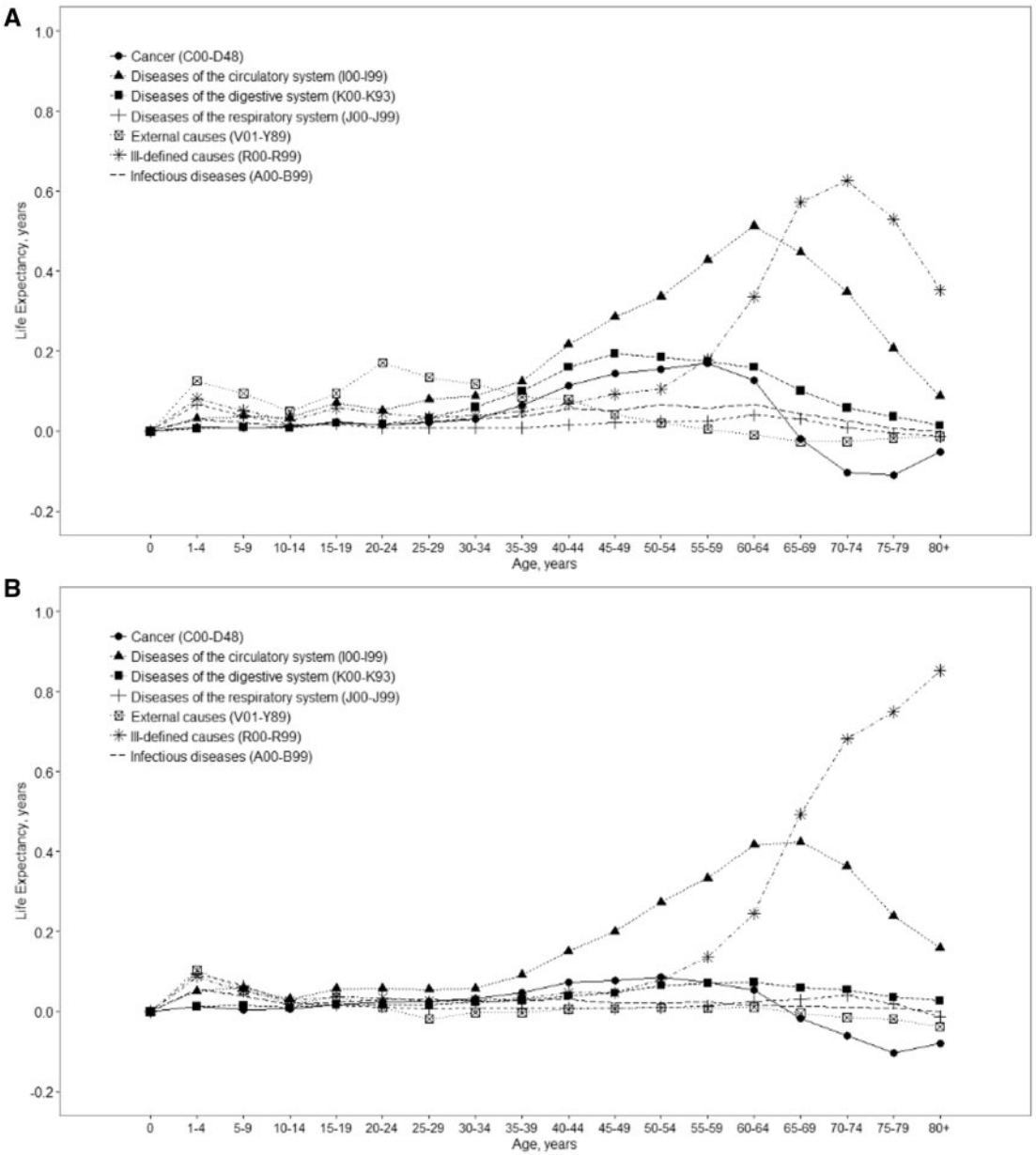

Figure 2 Age- and cause-specific contributions to life the expectancy gap between North and South Korea in 2008 (South Korea respect to North Korea). (A) Men and (B) women (The age- and cause-specific mortality data from South Korea in 1985 for men and in 1984 for women were used as proxies for the North Korean data in 2008)

pressure among North Korean male and female participants in the 2008 WHO STEPS generally reflected the past South Korean situations.[1] The westernization of nutritional intake occurred in South Korea beginning in the 1980s.[37] Studies of North Korean refugees have shown that refugees who defected after the food shortage had a higher prevalence of digestive, circulatory and infectious diseases than South Koreans, and that the prevalence of those diseases among North Korean refugees increased after the food shortage.[33,38,39] Meanwhile, it should be noted that the age-specific contributions to the LE difference were determined using actual mortality data collected from the two Koreas. When we compared the proportion of causes of death in South Korea in the early 1990s to those of North Korea in 2015 using the causes of death data provided by the GBD study, the causes of death between the two countries showed generally similar distributions (Supplementary figure S1). Second, the quality of South Korean cause-specific mortality data in mid-1980s is less than optimal,[30] because the proportion of death certifications by physicians was not high in the mid-1980s.[40] Senility (ICD-10 R54) accounted for most of the ill-defined causes of death in the mid-1980s.[30] Based on a community survey in South Korea employing medical records prior to death and face-to-face interviews of the next of kin or neighbours, cardiovascular disease was found to account for the largest proportion of deaths with ill-defined causes and the distribution of the actual causes coded for ill-defined causes was similar to the distribution of registered causes in death certificates.[41] Therefore, the presence of ill-defined causes might have obscured the contribution of major causes of death to the LE difference between the two Koreas to some extent.

In this study, we attempted to provide explanations of the tremendous difference in LE between North and South Korea by exploring the age- and cause-specific contributions to the LE difference. Since no domestic or international attempts to perform a population-based survey of cause-specific mortality in North Korea are being made, the results of our analysis provide important insights on the current status of North Korean mortality and the LE difference

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between the two Koreas. This study also underscores the urgency of South Korean and international humanitarian aid programs to reduce the mortality rate of the North Korean people and subsequently attenuate the LE difference between the two Koreas.

Supplementary data

Supplementary data are available at *EURPUB* online.

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Conflicts of interest: None declared.

Key points

- During the 15-year period between 1993 and 2008, the LE gap between the two Koreas substantially increased. The LE in South Korea rose by 6.4 years between 1993 and 2008, whereas the LE in North Korea decreased by 3.5 years.
- The LE gap between the two Koreas was largely attributable to increased discrepancies in mortality among children younger than 1 year of age and adults 55 years of age or older. Circulatory diseases, digestive diseases, infant mortality, external causes (for men), cancers (for men) and infectious diseases were the major cause-specific contributors to the increased LE gap between the two Koreas.
- The urgency of South Korean and international humanitarian aid programs is needed to reduce the mortality rate of the North Korean people and subsequently attenuate the LE difference between the two Koreas.

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