

# Age- and cause-specific contributions to income difference in life expectancy at birth: findings from nationally representative data on one million South Koreans

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**Background:** Income is not frequently used to monitor health equity on a national level largely due to the lack of public data on income. Information on income allows policy makers to identify the economically disadvantaged population in a country directly. We examined differences in life expectancy (LE) at birth by income and quantified age- and cause-specific contributions to the LE differences using national health insurance data. **Methods:** Data from a nationally representative sample of 1 097 333 South Koreans (2% of the total population) collected between 2002 and 2010 (39 737 deaths) were used. National health insurance premiums were used to estimate income level. Age- and cause-specific contributions to differences in LE at birth by income were estimated using Arriaga's decomposition method. **Results:** LE at birth gradually increased with income in both genders. Interquintile income LE differences were 7.93 years in males and 3.82 years in females. Most of LE differentials were attributed to differences in mortality in middle-aged and older adults. Suicide and cerebrovascular accidents were the two leading causes of death contributing the most to income LE differences in both males and females. The top 10 causes of death accounted for over 50% of the total LE differences by income in both genders. Alcohol-related causes of death explained the majority of the gender differences in the income LE differentials. **Conclusions:** Income differentials in LE at birth according to national health insurance premiums and data linkage systems could provide a valuable opportunity for monitoring and prioritizing population health inequalities in South Korea.

## Introduction

Socio-economic inequality in health is an important public health concern across the world.<sup>1,2</sup> In the past 15 years, health inequalities have become the subject of academic investigation and policy attention in South Korea.<sup>3</sup> In the 2010 and 2020 national health plans of the South Korean government, the enhancement of health equity became one of two overarching goals.<sup>3</sup> However, one important challenge in South Korea is determining the best quantitative methods to monitor the overarching goal for health equity.

Many countries have a quantifiable national goal or target for health equity.<sup>4,5</sup> Socio-economic inequality in life expectancy (LE) is one frequently used summary measure for monitoring health inequalities.<sup>4–6</sup> Most countries have used occupational class, geographic measures (e.g. deprivation) or education as indicators of socio-economic position (SEP) in measuring inequalities in LE.<sup>6–11</sup> However, income is less frequently used as an indicator largely due to the lack of information on income in public data.<sup>12–15</sup> Nevertheless, income has many advantages as an SEP indicator for achieving a national health equity goal. Information on income allows policy makers to identify the economically disadvantaged population in a country directly. Many social and health policies/programmes have been directly developed considering income levels in South Korea.<sup>16</sup> Using income as the main SEP indicator to achieve overarching goals for health equity may allow policy makers to develop programmes and policies that are better at

targeting economically vulnerable populations than the current ones are.

In South Korea, data infrastructures are used to monitor inequalities in LE by income.<sup>17</sup> South Korea's National Health Insurance (NHI) provides healthcare coverage to the entire population as well as maintains a complete mortality data registry.<sup>17,18</sup> Unique personal identification numbers in both the NHI data and mortality data allow for efficient data linkage. The premium for each person set by the NHI reflects individual's income level during the previous year.<sup>17,19–21</sup> These infrastructures provide a unique opportunity to monitor inequalities in LE by income in South Korea.

Inequalities in LE can be decomposed into age- and cause-specific components because the inequalities in total mortality rates are the sum of the inequalities in age- and cause-specific mortality rates.<sup>22,23</sup> In the past decade, several studies have reported on the contributions of age groups and causes of death to socio-economic inequalities in LE.<sup>13,14,17,18,23–26</sup> These prior studies have indicated that the leading causes of death contributing to the inequalities in LE differ by country.<sup>14,17,18,25</sup> Decomposition of inequalities in LE by age groups and causes of death may provide valuable information on high-priority areas for the implementation of interventions and policies to reduce health inequalities. To this end, we aimed to examine differences in LE at birth by income and to quantify age- and cause-specific contributions to the LE difference using nationally representative mortality data on one million South Koreans.

## Methods

### Data

The data used in this study are available from National Health Insurance Service (NHIS) that manages the operation of South Korea's NHI. The NHIS constructed the NHI database from 2002 to 2010, which is a sample of the entire South Korean population, ~50 million people. These sample data were linked to other data on socio-demographic variables, mortality, medical service utilization and health examinations using unique personal identifiers. Although this cohort data could be a valuable resource for epidemiologic research, public use of these data has been restricted because of concerns regarding privacy and confidentiality. Recently, the NHIS publicly released an anonymized 2% sample (one million people) of the cohort database for research purposes, which we used in this study.

In this study, we used beneficiary data on 1 097 333 individuals collected between 2002 and 2010. From the 2002 data, a total of 1 025 340 were included as study subjects. Each year between 2003 and 2010, random samples of new infants were added to compensate for the loss of samples due to death or emigration (Supplementary table S1). Mortality follow-up data of these new infants during the study period were also used and provided us with more stable estimates for infantile and early childhood mortality rates for the calculation of LE at birth. For example, only eight infantile deaths were available in the mortality follow-up data of the baseline samples in 2002, whereas we could use 44 infantile deaths with newly added infantile data between 2003 and 2010. Analysis using data without those newly added infants produced similar patterns in LE at birth (Supplementary table S2). The individual data were linked to the mortality data provided by Statistics Korea using each individual's unique 13-digit personal identification number. By South Korean law, all deaths of Korean nationals must be reported to Statistics Korea. Therefore, mortality data in South Korea are considered complete and the accuracy of cause-of-death information improved over the past two decades.<sup>17,18</sup> Of the 1 097 333 males and females from birth age and older, 39 737 of these individuals died between 2003 and 2010 (Supplementary table S2). The date and causes of death for these individuals were obtained from the mortality data of Statistics Korea. Causes of death were coded using the International Classification of Disease, Tenth Revision (ICD-10) codes.

### Income measurement

The NHI-determined premium levels were used to estimate income. Prior studies in South Korea have used these premium levels as an SEP indicator.<sup>17,19–21</sup> The NHI premiums for those not self-employed are proportionally imposed on the average monthly salary over the previous calendar year, while that for the self-employed are based on their taxable income, assets and indicators of living standards (e.g. car ownership). Those in the Medical Aid Programme (3% of the total South Korean population) are exempt from NHI premiums. The NHI premiums are calculated at the same time each year for the entire Korean population. These premium levels are applied to all age groups because dependents of the employed NHI beneficiary share the same premiums. A total of 41 premium levels (20 premiums for those not self-employed, 20 premiums for those self-employed and 1 premium for Medical Aid receivers) were grouped into quintiles based on the population size for each premium level. When we separately analyzed the data for those not self-employed and those self-employed, we found similar patterns in both LE inequalities and age- and cause-specific contributions as presented in this study (data not shown).

### Statistical analysis

Variables included in our analysis were sex, age, income quintiles and causes of death over the period between 2002 and 2010. Using a

person-year approach with the numbers of all NHI beneficiaries and deaths, we calculated 1-year age-specific mortality rates for single years of attained age during the follow-up period. Then, we combined the data and constructed 5-year (<1 year, 1–4 years, 5–9 years, 10–14 years, ..., 80–84 years, 85 years and over) probabilities of death. For LE at birth, life tables were constructed using the 5-year probabilities of death by income level. Estimated LE was compared among the income quintiles. We employed Arriaga's LE decomposition method,<sup>27,28</sup> which is widely used in population studies.<sup>23,29,30</sup> Because total mortality rates are the sum of the age- and cause-specific mortality rates, LE can be the sum of the age- and cause-specific contributions. Moreover, since socio-economic differences in total mortality are the sum of the socio-economic differences for age- and cause-specific mortality, we can also decompose the socio-economic differences in LE into the age- and cause-specific contributions. Gender differences in income LE differentials were also decomposed. In addition to the detailed causes of death, four broad causes of death including all cancers (ICD-10 codes, C00–C96), all cardiovascular diseases (ICD-10 codes, I00–I99), all external causes (ICD-10 codes, V00–Y99), and all other causes were considered in our analyses.

## Results

As shown in Supplementary table S2, 39 737 deaths occurred during 7 872 578 person-years of follow-up. The average LE at birth was 79.27 years for the total population, 75.74 years for males, and 82.72 years for females (Supplementary figure S1). The difference in LE at birth between genders was 6.98 years. This average LE at birth for males and females corresponds to the official data from Statistics Korea during 2006–07 (75.74 years for males in 2006 and 82.73 for females in 2007), which is the mid-point in our cohort period (2002–10).

Figure 1 and Supplementary table S2 show the stepwise patterns of the income differentials in LE at birth. LE differences between the highest and the lowest income quintiles were 7.93 years in males and 3.82 years in females, displaying a greater LE difference by income in males than in females (gender difference = 4.11 years). In addition, female LE at birth in the lowest income quintile was found to be greater than the male LE at birth in the highest income quintile.

Figure 2 presents the age-specific contributions in years to the total LE difference between the highest and the lowest income quintiles. Supplementary tables S3 and S4 show age-specific contributions (absolute year contributions and percent contributions) for the male and female income groups, respectively, with the highest income quintile being referent. As displayed in figure 2, all age groups contributed positively to LE differentials by income in both males and females, thus indicating that the mortality rates in the lowest income quintile were greater than the mortality rates of the highest income quintile in all age groups. Most of the age-specific contributions occurred in middle-aged and older adults. For example, the contributions by age groups between 40 and 69 years accounted for 64 and 53% of the total LE differences in males and females, respectively. Figure 2 also shows that gender differences in income LE inequalities occurred mainly among those aged 35–64 years.

Figure 3 shows cause-specific contributions to the total LE differences between the highest and the lowest income quintiles. When the four broad causes of death were analyzed, all other causes of death not including cancers, cardiovascular diseases and external causes were the leading causes of death contributing to total LE differentials by income. In males, cancers and external causes were relatively high contributors, whereas in females cardiovascular diseases were relatively high contributor. Supplementary figures S2 and S3 present the age- and four broad cause-specific contributions to LE differences in Korean males and females, respectively. Contributions by external causes in male and female young adults were greater than

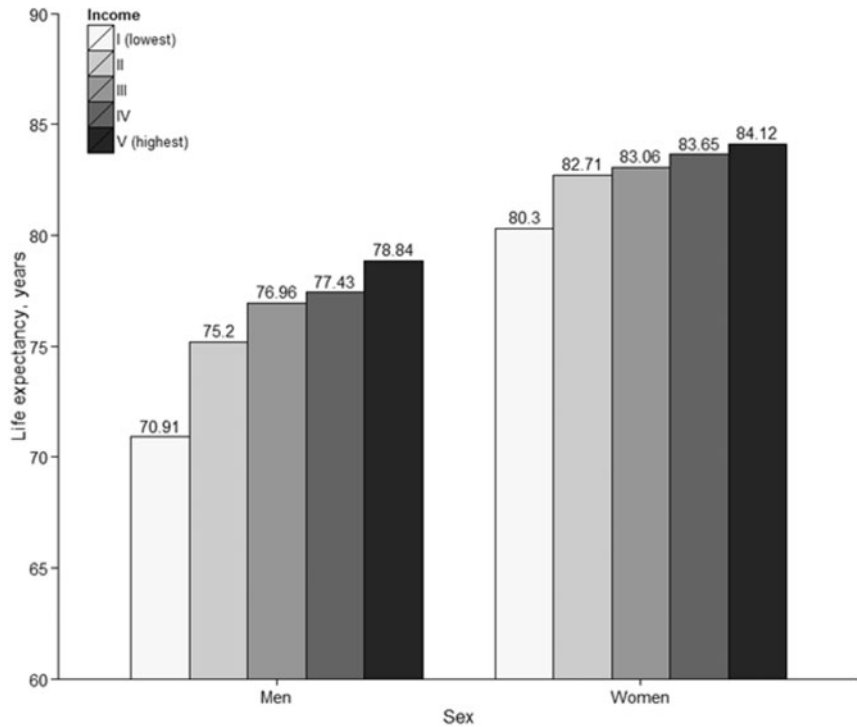


Figure 1 LE at birth by gender and income quintiles in a nationally representative sample of South Koreans, 2002–10

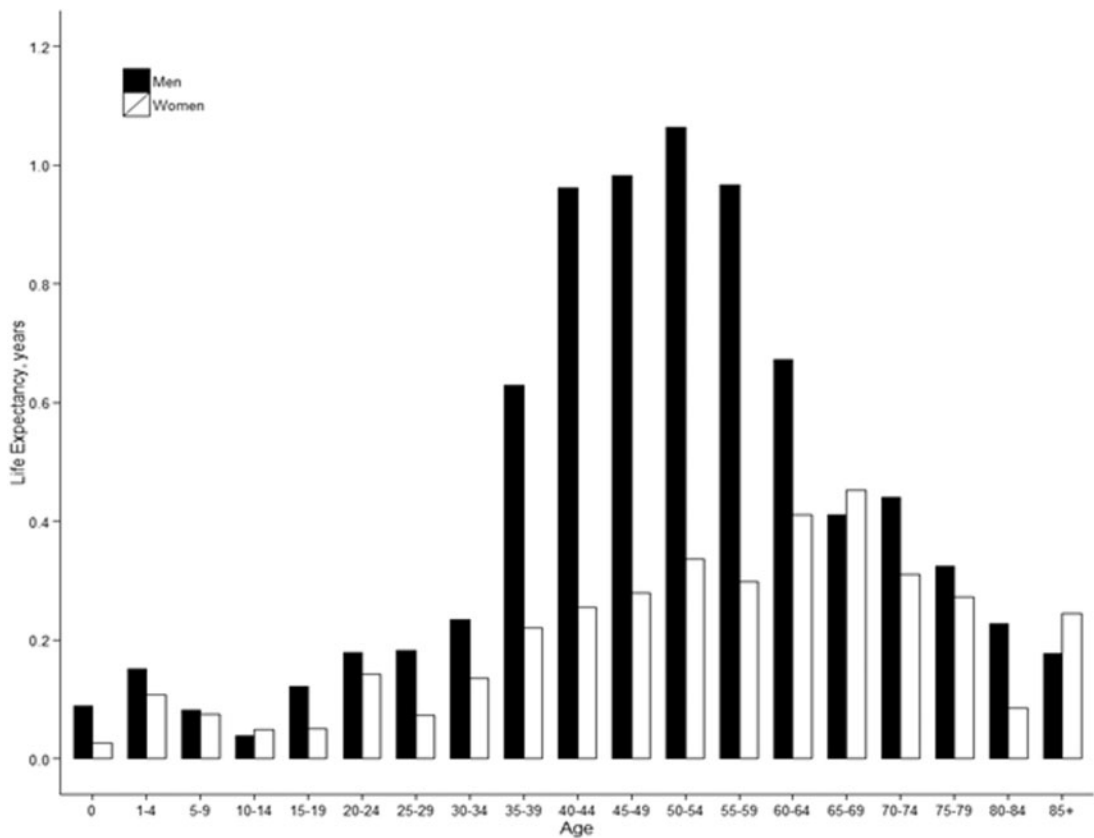
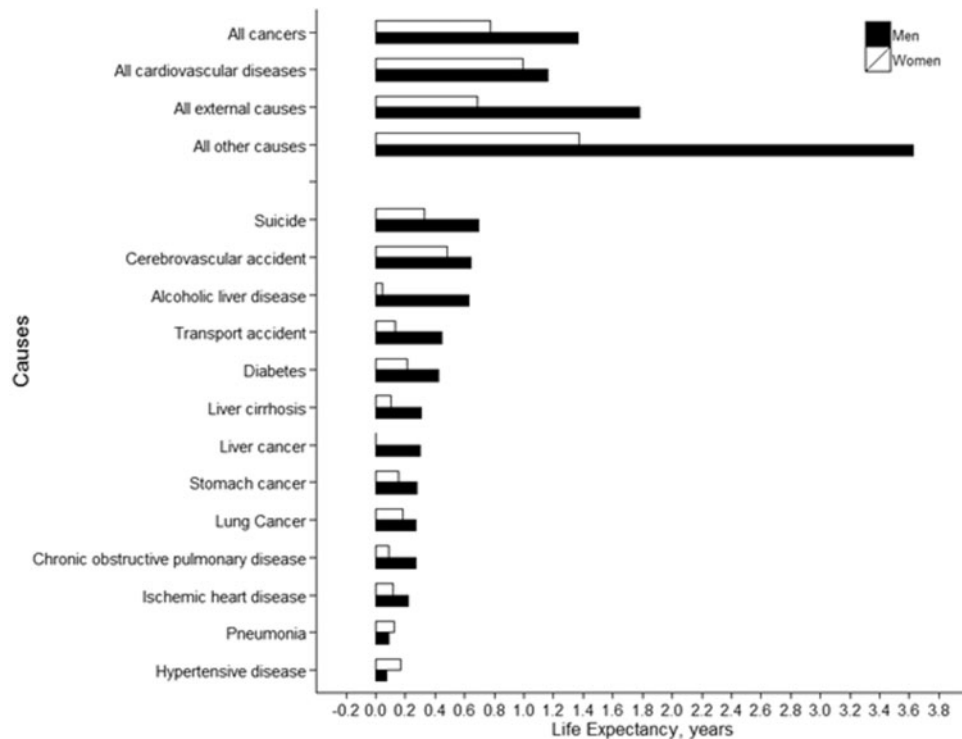


Figure 2 Differences in the age-specific contribution to total LE between the highest and the lowest income quintiles for males and females

the contributions by the other three broad causes. In older adults, contributions by all other causes and cancers were high contributors in males, while all other causes and cardiovascular diseases were high contributors in females.

Figure 2 also shows the contributions by specific causes. Supplementary tables S5 and S6 present cause-specific contributions (absolute year contributions and percent contributions) between income groups when the highest income quintile was the referent.



**Figure 3** Differences in the cause-specific contributions to total LE between the highest and the lowest income quintiles for males and females

In males, suicide, cerebrovascular accidents, alcoholic liver disease, transport accidents, diabetes, liver cirrhosis, liver cancer, stomach cancer, lung cancer and chronic lower respiratory disease were the top 10 leading causes of death, accounting for 54% of the total LE differences by income. In females, cerebrovascular accidents, suicide, diabetes, lung cancer, stomach cancers, hypertensive disease, transport accidents, pneumonia, ischemic heart disease and liver cirrhosis were the top 10 leading causes of death and accounted for 52% of the total LE differences by income.

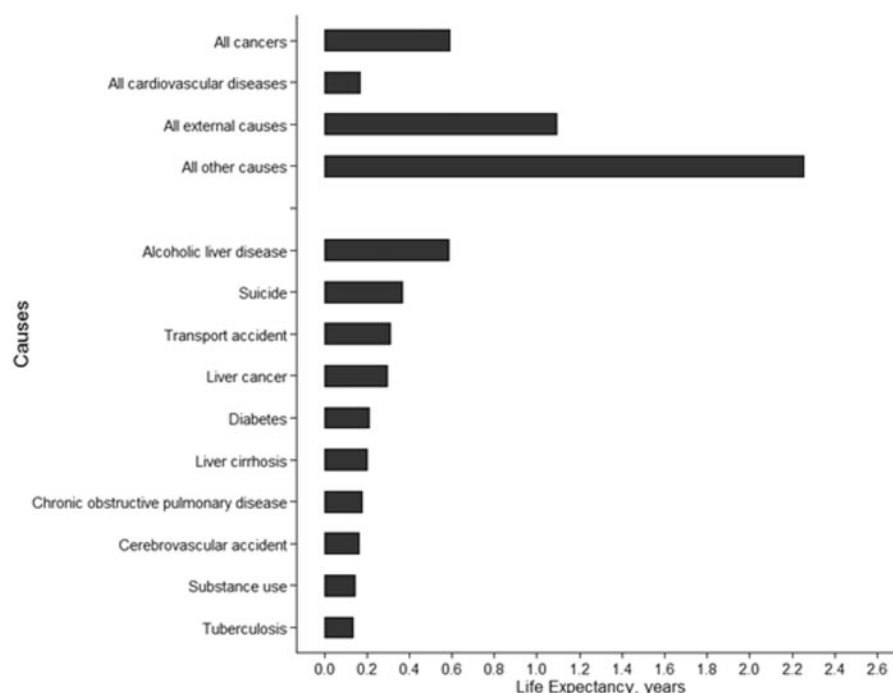
Figure 4 and Supplementary table S7 show the cause-specific contributions to gender differences for the socio-economic LE differences (gender difference = 4.11 years). Of the four broad causes of death, all other causes were the major contributor to the gender difference, while contributions by cardiovascular diseases were relatively small. Of the detailed causes of death, the top 10 leading causes of death contributing to gender differences in total socio-economic LE differences were alcoholic liver disease, suicide, transport accidents, liver cancer, diabetes, liver cirrhosis, chronic lower respiratory disease, cerebrovascular accidents, substance abuse and tuberculosis. These top 10 causes accounted for 63% of the total gender differences in LE at birth.

## Discussion

This nationally representative study provides data on inequalities in LE at birth by income. Because the NHI premiums reflecting income levels are annually updated and individual linkage of these data with complete mortality data are possible in South Korea, this study exemplifies the use of regular monitoring for the overarching goal of health equity in our national health plan using NHI-mortality linked data. Although socio-economic inequalities in LE according to education level and area deprivation has been calculated in South Korea,<sup>18,31,32</sup> obtaining health equity across income levels remains an important goal because many policies and programmes are directly related to income levels. Beneficiaries of social welfare policies and programmes including the Basic Livelihood Security programme and the Basic Old-Age Pension are determined based

on means tested income in South Korea.<sup>16</sup> Indicators on health equity in the National Health Plans used income as the main SEP indicator.<sup>3</sup> In the annual Korea Health Statistics report using Korea National Health and Nutrition Examination Survey, income have been used as the main indicator for annual monitoring of inequality in health status and health behaviours by the Korea Centres for Disease Control and Prevention.<sup>33</sup> In addition, many government programmes in South Korea related to healthcare services (e.g. the national health insurance coverage and the national health screening programmes) are based on NHI premiums.<sup>16</sup> For other social services including government funded babysitting services and voucher programmes for the elderly (e.g. daycare services, home visits and household-related services), beneficiaries are identified based on their NHI premiums.<sup>16</sup> Thus, regular monitoring of inequalities in LE at birth by income will help to inform policy makers to develop health and social policies that directly aim at closing the gap between these socio-economic groups. In addition, using the methodology employed in the present study, annual monitoring of income differences in LE at birth by analyzing the entire NHIS database may be possible.

Results of this study showed socio-economic gaps in LE at birth. The LE difference in males (7.93 years) according to income was greater than the gender difference in LE difference between males and females (6.98 years). The interquintile income difference in LE found in this study was greater than the interquartile income difference in a previous Korean paper that used mortality data on Korean public servants and their dependents,<sup>17</sup> but smaller than the interquintile income difference recently reported in Finland.<sup>15</sup> The income difference in LE of this study was also smaller than the LE differences in South Korea between education statuses (elementary vs. college education),<sup>18,31</sup> which might be because those who attended only elementary school tend to be in a very low SEP in South Korean society. In addition, the LE gaps between the lowest income quintile group and the second lowest income quintile group were greater in both genders than any other neighbouring between-group gaps, indicating a non-linear relationship between income



**Figure 4** Cause-specific contributions to gender differences in the interquintile income differences in LE at birth

and mortality.<sup>34,35</sup> One reason for this large difference might be that the lowest income quintile group was comprised of those in the Medical Aid Programme and those with the lowest income among the self-employed.

This study presented that, in terms of age-specific contributions, most of the contributions occurred in adulthood and the elderly period. Contributions by age groups between 40 and 69 years were 64% in males and 53% in females of the total income differences in LE. Contributions by those aged 70 or older years were also significant in females (23.8% among females aged 70 or older). Prior Korean studies have shown that the contributions by infant and childhood mortality rates on both LE increase and gender differences in LE have diminished over the decades and most of the contributions to both LE increase and gender LE differences were found among middle-aged and older Korean adults in the recent decade.<sup>29,30</sup> Thus, the limited contributions by infant and childhood mortality and increased contributions by middle-aged and older adults may be inevitable.

The results of our study showed that, among the four broad causes of death, contributions by all other causes were the greatest in both genders. In males, cancers were relatively high contributors, whereas cardiovascular diseases were high contributors in females. In contrast to the findings from studies in Western countries,<sup>14,25</sup> the contribution of ischemic heart disease was not substantial. Suicide was the highest contributor in males and second in females, accounting for ~8–9% of the total LE differences by income. Since 2003, South Korea has the highest suicide mortality rates among Organization for Economic Co-operation and Development member countries.<sup>36</sup> Moreover, suicide was the second leading cause of death in South Korea in terms of years of life lost in 2010.<sup>37</sup> The results of our study also showed that cerebrovascular accidents contributions to LE inequalities were substantial, the leading contributor in females, and the second highest contributor in males. The previous Korean studies have indicated that cerebrovascular accidents substantially contribute to all-cause mortality, mortality inequalities, LE increases and decreases in gender LE differences.<sup>21,29,30</sup>

In this study, we identified the top 10 causes of death that most contribute to total LE differences by income. Suicide,

cerebrovascular accidents, transport accidents, diabetes, liver cirrhosis, stomach cancer and lung cancer were included in the top 10 lists in both males and females. In males, alcoholic liver disease, liver cancer and chronic lower respiratory disease were also in their list, whereas hypertensive disease, pneumonia and ischemic heart disease were also in the top 10 list for females. These top 10 causes accounted for ~54 and 52% of the total LE differences in males and females, respectively. These findings suggest that relatively small sets of policy measures might effectively address socio-economic health inequalities. In addition, cause-specific approaches might better guide policy makers to develop effective policies to reduce inequalities in LE.

Our analysis results revealed that gender difference in LE inequalities by income was 4.11 years. The top 10 causes of death contributing to the gender differences accounted for 63% of the total gender difference. The top 10 causes of death include alcohol-related conditions such as alcoholic liver disease, suicide, transport accidents and liver cancer.<sup>38</sup> Alcohol is an important risk factor causing higher mortality risks in more disadvantaged populations.<sup>39</sup> A recent comparative risk assessment in the Global Burden of Disease Study showed that alcohol consumption caused the greatest disease burden (in both years of life lost and disability adjusted life years) in South Korea.<sup>37</sup> Other top contributing causes of death to the gender difference in LE inequality in this study were related to psychosocial issues (suicide and substance use), tobacco use (chronic obstructive pulmonary disease and tuberculosis) and outdoor activities (transport accidents).

The present study has several limitations. First, the NHI premium levels were used to represent income levels. For dependents of NHI beneficiaries (e.g. unemployed spouses, children, students and the elderly), the NHI premiums likely do not represent the dependents' actual income levels and thus might have resulted in an underestimation of the socio-economic LE differences. Second, ill-defined causes of death accounted for 9.1% (1996 of 22 002) and 18.2% (3224 of 17 735) of the total deaths among males and females, respectively. The contributions of ill-defined causes to income differences in LE were 8.1% in males and 4.2% in females, indicating greater mortality rates from ill-defined causes in the lowest income quintile than those in the highest income quintile. The



relative percent contribution to LE differences was smaller than the relative percent contribution to the total number of deaths because these ill-defined causes were frequently assigned to the elderly aged 65 or over.

This study also has several strengths. First, a large, nationally representative sample of South Koreans was used. The study findings represent the current status of income differences in LE at birth and corroborate the findings of a previous study on the relationship between income and mortality using mortality follow-up data of Korea National Health and Nutrition Examination Survey.<sup>40</sup> Second, the methodology used in this study may be applied to the future monitoring of health inequalities using the NHI database. Provincial-level monitoring of income differences in LE is also needed. In addition, calculations of healthy LE at birth using morbidity and mortality data from the NHI database might also be possible by applying the present methodologies.

In conclusion, income differentials in LE at birth with NHI premiums and data linkage systems in South Korea could provide a valuable opportunity for monitoring health inequalities at the population level. Exploration of age- and cause-specific contributions to income differences in LE at birth could be used to find targeted priority areas for future policies and interventions.

## Supplementary data

Supplementary data are available at *EURPUB* online.

## Acknowledgements

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*Conflicts of interest:* None declared.

### Key points

- LE at birth gradually increased with income in both genders. Interquintile income differences in LE at birth were 7.93 years in males and 3.82 years in females.
- Suicide and cerebrovascular accidents were the leading causes of death contributing most to the LE differences by income. Top 10 causes accounted for 54 and 52% of the total income differentials in LE at birth in males and females, respectively.
- Alcohol-related causes of death were the leading causes of death contributing to gender differences in income inequalities in LE.

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## Educational inequality as a predictor of rising back pain prevalence in Austria—sex differences

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**Background:** Back pain (BP) represents a widespread public health problem in Europe. The morbidity depends on several indicators, which must be investigated to discover risk groups. The examination of trends in socioeconomic developments should ensure a better understanding of the complex link between socioeconomic-status and BP. Therefore, the role of social inequalities for BP has been investigated among Austrian subpopulations over a 24-year period. **Methods:** Self-reported data from nationally representative health surveys (1983–2007) were analyzed and adjusted for self-report bias ( $N=121\,486$ ). Absolute changes (ACs) and aetiologic fractions (AF) were calculated to measure trends. To quantify the extent of social inequality, the relative index of inequality was computed based on educational levels. **Results:** The prevalence of BP nearly doubled between 1983 and 2007. When investigating educational groups, subjects with low educational level were most prevalent. Obese persons generally showed higher rates of BP than non-obese subjects. Continuously rising trends across the different educational groups were more evident in men. The AC was highest in obese men with high education (+32.9%). Education-related inequalities for BP were more evident in men than women. **Conclusion:** Educational level is an important social indicator for BP. A gradient for low to high educational level in the trends of BP prevalence was clearly identified and stable only among men. We presume that the association 'education' and 'physical workload leading to BP' is more relevant for men than for women. The implementation of effective approaches to BP, in combination with target group-specific interventions focusing on educational status, is recommended.

## Introduction

The prevalence of back pain (BP) has strongly increased on a global scale over the last decades and even reached epidemic levels in many European countries.<sup>1–3</sup> It considerably affects the quality of life, as it may cause severe pain and limitations to physical activity.<sup>1</sup> In addition, the increased use of health care resources, and especially indirect costs—e.g. for disability pension or absenteeism—have brought about a rise in the total public spending for BP.<sup>4,5</sup> Now a highly prevalent non-communicable complaint, BP is of prime public health importance.<sup>2,3</sup>

A preliminary study had shown evidence for a strongly increasing BP prevalence in Austria. By 2007, about one-third of the adult population was affected by BP. The most undesirable trends occurred in women, aged 75 years and older, and in obese persons.<sup>6</sup> Further studies found obesity or a higher BMI to be associated with BP.<sup>7–9</sup> The strong rise in obesity prevalence had led to a parallel upward trend in the prevalence of different associated diseases and disorders, including BP.<sup>10</sup> However, the morbidity of BP depends upon several other environmental and personal indicators that should be investigated to discover risk groups.<sup>11</sup> It is thus recommended to investigate trends in socioeconomic developments to understand the complex relationship between socioeconomic status (SES) and BP.<sup>12</sup>