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Building D, 370 Sicheong-daero, Sejong City 30147 KOREA Korea Institute for Health & Social Affairs

Trends in and Characteristics of Mortality Inequality by Education Level in Korea[1)]

Hae-Bong Woo
Research Fellow, KIHASA

Introduction: mortality inequality in times of population aging

The marked gains that the past century has added to life expectancy represent one of humanity's most significant achievements during that time period. The life expectancy increase that occurred before the 1950s can be attributed mostly to declines in infant mortality. From the century's second half on, however, life expectancy gains have been driven primarily by reductions in old-age mortality.[2)] Such changes had to do with the epidemiological transition. In the early phase of the transition, mortality declines were attributed in large part to declines in death from infectious diseases. Reductions in mortality rate in recent years have been increasingly attributed to declines in death from cardiovascular disease, a key cause of death for older adults.[3)]

In the 1950s and 1960s, life expectancy at birth was lower in Korea than in most of the countries that are now members of the OECD. According to the United Nations World Population Prospects (2019), women's life expectancy in Korea was the third-highest in all OECD countries for the period

1) This brief is an amended extract *from Mortality Transition and Differential Mortality in South Korea: Analysis and Policy Directions* (2021), authored by Hae-Bong Woo, Insu Chang, and Hee-Sun Jung.

2) Oeppen, J., & Vaupel, J. W. (2002). Broken limits to life expectancy. Science, 296(5570), 1029-1031.

3) Crimmins, E. M. (2015). Lifespan and healthspan: Past, present, and promise. Gerontologist, 55(6), 901-911.

2015~2020, while Korean men's ranked fifteenth.[4)]

The mortality decline that occurred in Korea in the past had played out on a "universal" scope, presumably as a result of an across-the-board improvement in living standards and public health conditions. In the recent decades, however, it was the declining old-age mortality that played large part in driving up life expectancy. Health and death in old age are in a sense a result of the opportunity structure that spans the life course and of life experiences as accumulated within it. In that respect, given the growing socioeconomic inequality in Korea, mortality inequality comes as a cause for no small concern.[5)]

In the current circumstances where the need is growing for understanding how mortality dynamics and inequality pan out in lockstep with population aging, this study looks into socioeconomic mortality differentials and draws implications for policy. Though there are many indicators in use to represent different socioeconomic groups, socioeconomic mortality differentials in this study are examined between groups of different education levels, as education, looked on here as elsewhere as affecting income, "improves health" by "enhancing a sense of personal control that encourages and enables a healthy lifestyle."

The data and measures used for analysis

The data used for this study come from the Population Trend Survey (death certificate data), the Population and Housing Census, and the "Midyear Registered Resident Population". For population dynamics estimates, this study used projected mid-year population statistics (for years 1985 through 1992) and registered-resident population statistics (for years 1993 through 2015). This study examined two education groups, those with a high school diploma or less and those with a college diploma or more. Such classification is due to the limited availability of data. The education-level-specific mortality rates that are available for use are those concerning the years since 1983. It should also be noted that it was in 1993 that the category of those with secondary education was broken down into those with a middle-school diploma and those with a high-school diploma.

The population of each education level was estimated by applying the education-level-specific population proportion (by sex and age) derived from the Population and Housing Census to either the projected population or the registered-resident population. The upper age limit for people whose education level is reported in the Population and Housing Census has been raised from 60 years in 1995 to 70 years in 2000 and to 85 years in 2005. The lowest of the age brackets that this study sought to examine consists of those aged 30 to 34, the age range by which college education is assumed to have been completed.

4) United Nations [UN]. (2021). World Population Prospects 2019. Retrieved from https://population.un.org/wpp/ 2021. 4. 14.

5) Mirowsky, J., & Ross, C. E. (2003). Education, Social Status, and Health. New York: Aldine De Gruyter.

Given the limited availability of data, this study, instead of drawing on real-world observation, constructed period life tables for men and women of different education levels by using age-specific mortality rates that had been adjusted using such demographic techniques as Brass relational logit model and the P-Spline approach. Then, a smoothing was performed for all ages from 30 to over 100, under the assumption that the education-level-specific mortality rates for ages 90 and over were equal to Statistics Korea's mortality rate for the whole population.

[Table 1] The data used for mortality estimation by education level and age bracket, 1985~2015

Age	education level	1985	1990	1995	2000	2005	2010	2015
30~34	High school or less	Death registration records + population estimates		Death registration records + registered population				
	College or more							
35~39	High school or less							
	College or more							
40~44	High school or less							
	College or more							
45~49	High school or less							
	College or more							
50~54	High school or less							
	College or more							
55~59	High school or less							
	College or more							
60~64	High school or less	No available data	No available data	No available data	No available data			
	College or more							
65~69	High school or less							
	College or more							
70~74	High school or less							
	College or more							
75~79	High school or less							
	College or more							
80~84	High school or less							
	College or more							

Source: 1) Statistics Korea. (2021). KOSIS. https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B80A15&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1PM2001&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B04006&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1BPA001&conn_path=I2

For analysis of mortality differentials, this study examined central tendency measures and dispersion measures. The central tendency indicator used here is the modal age at death. For measuring dispersion of length of life, this study used the shortest age interval (C50) where 50 percent of deaths occur. Both indicators have been used extensively since the 2000s.

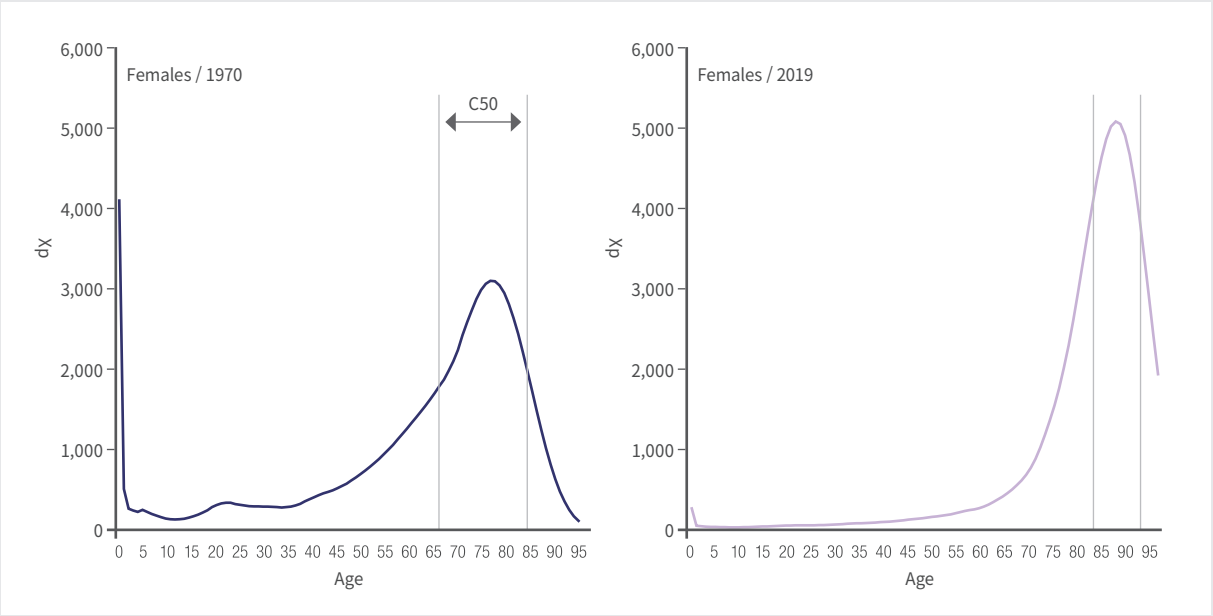
The human lifespan on the whole displays a bi-modal mortality distribution with two peaks, one in infancy and the other in old age. However, the demographic interest is predominantly in the second peak, as it is the modal age at death of older adults that captures the "typical" length of life. For a country like Korea where length-of-life gains are due mostly to old-age mortality declines, the modal age at death, solely determined by old-age mortality, is preferred over life expectancy, an indicator determined by the mortality rates of all age groups.

As is the case with life expectancy, the modal age at death can be calculated based on period life tables. In the formula below, d denotes the estimated number of deaths occurred in people of a given age, and x refers to the age at which most deaths occur.

$$M = x + \frac{d(x) - d(x-1)}{[d(x) - d(x-1)] + [d(x) - d(x+1)]}$$

C50, an indicator of age-at-death variability, measures the shortest age span in which 50 percent of deaths occur centered around the modal age at death. Configured based on Statistics Korea's life tables for women, Figure 1 is a graphical representation of how from 1970 on the age span in which 50 percent of deaths take place has been increasingly compressed into a narrower interval. Both the modal age at death and C50 are measures estimated from period life tables, as is the case with Statistics Korea's life expectancy at birth, a better-known indicator. These estimates are obtained using a hypothetical cohort postulated to be subject across its lifetime to the age-specific mortality rates (with the age range spanning from 30 to over 100) observed in a particular time period (for example, at a particular year). It should be noted thus that the indicators M and C50 as used in this study are not to be construed as representing the mortality experience of real-world cohorts.

[Figure 1] A visual representation C50: from 1970 (left) to 2019 (right)



Source: 1) Statistics Korea. (2021). KOSIS. https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B42&conn_path=I2

Mortality inequality by education level: trends and features

For 2015, there was a gap of around 3 years in modal age at death between men with a high school diploma or less (83.96 years) and men with a college diploma or more (86.90 years). For women, the difference between the two education groups was much smaller at less than a year (89.71 years vs. 90.34 years). Compared to the life expectancy at birth, another indicator often used as a measure of the central tendency of length of life, the modal age at birth was higher. The modal age at death was estimated to be higher by 4 to 5 years than life expectancy at birth even for the group of people with a high school diploma or less. That life expectancy at birth is lower than the modal age at death may be due to premature mortality. As deaths occur concentrated in older adults, as they increasingly have in recent years, the gap between life expectancy at birth and the modal age at death tends to narrow.

In the period between 1985 and 2015, the mortality gap between the two education groups as examined in terms of the modal age at death, a measure of the central tendency, has narrowed by and large as time went on. The narrowing of the gap is due to the fact that across that time period, the modal age at death has increased more among those with a high school or less education than among those with a college degree or more, for men and women alike. As shown in Table 2, the between-group mortality gap for men and women, estimated to be 5.54 years for men and 2 years for women in 1985, narrowed in 2015 to 2.94 years and 0.63 years, respectively.

[Table 2] Mortality differentials between two education groups, 1985~2015

			1985	1990	1995	2000	2005	2010	2015
Men	High school or less	M	73.43	75.97	77.67	79.23	80.93	82.66	83.96
		C50	18.76	18.29	17.90	17.13	16.40	15.91	15.51
	College or more	M	78.97	80.26	82.42	83.01	84.70	85.76	86.90
		C50	15.42	15.00	14.10	13.95	13.07	12.88	12.51
Women	High school or less	M	82.91	84.08	85.51	86.18	87.42	88.94	89.71
		C50	15.65	14.67	14.09	12.95	12.65	12.49	12.19
	College or more	M	84.91	86.02	87.14	87.59	88.91	90.04	90.34
			13.69	12.76	12.39	11.42	10.93	10.99	10.74

Source: 1) Statistics Korea. (2021). KOSIS. https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B80A15&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1PM2001&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1B04006&conn_path=I2;
https://kosis.kr/statHtml/statHtml.do?orgId=101&tblId=DT_1BPA001&conn_path=I2

Mortality differentials between the two education groups were examined in terms not only of the central tendency but also of dispersion. For 2015 the shortest age interval where 50 percent of deaths occur was estimated to be 12.51 years for men with college education or more and 15.51 years for men with high school education or less. For women, too, the shortest age interval where 50 percent of deaths occur was longer for the low-education group at 12.19 years (as compared to the high-education group's 10.74 years). As was the case with the central tendency, the dispersion-based mortality gap was greater in men than in women.

Recap and concluding remarks

This study examined trends in mortality differentials between groups of different education levels for the period 1985~2015. Among the findings was that the modal age at death was lower and the length of life more varied in the low-education group. The length-of-life distribution by education level exhibited a greater central tendency and a greater variability in men than in women, a finding in line with previous studies conducted of differential mortality. However, a point meriting note is that the mortality differentials between groups of different education levels, as examined in terms of central tendency and dispersion, have narrowed in the three decades to 2015. This suggests that the pace at which improvements have occurred in mortality has been faster in the low-education group than in the higher-education group.

The fact that the length-of-life variance as measured by C50 is higher for the low-education group suggests that uncertainly about length of life is greater for individuals in this group. "Length of life" is a source of information essential to making optimal life decisions. The greater uncertainly about length of life in people of low socioeconomic status indicates that these individuals are more likely to face difficulties in making decisions concerning life events such as retirement. Moreover, decisions so made can affect their and their family's lives all the more.

Health and death really are of one process, though conceptually distinguishable, as most people go along a path leading through illness to death. This is to say that death can be looked on less as an event coming on independent of other phenomena and more as an outcome in which the complex process of health and functional decline culminates.

Barring unnatural deaths like those due to suicide or accidents, mortality is preceded as a rule by illness, as shown by various socioeconomic status indicators. Given this, the fact that the age-at-death variance is greater in groups of lower socioeconomic status suggests that these groups have greater health heterogeneity.

The age-at-death variance of groups of low socioeconomic status may well grow further, as it is more difficult for people in those groups, lacking as they are in both material and immaterial resources, to keep a healthy lifestyle across the lifetime.

Mortality gaps between groups of different education levels have kept narrowing until of late even as chronic diseases continued to bring on socioeconomic mortality differentials. However, the history of differential mortality suggests that to keep reducing socioeconomic between-group mortality differentials requires precise understanding and monitoring of mediating mechanisms that give rise to them.

Korea's epidemiological landscape has transitioned from infectious and parasitic diseases to chronic diseases as early as in the 1970s. Since the 2000s, reduction in deaths by cardiovascular diseases and malignant neoplasm has contributed considerably to length-of-life gains.

In the past when the leading causes of death were infectious and parasitic diseases, between-group mortality differentials were a problem that could be dealt with, with effect, by means of public health interventions and vaccination. However, in the epidemiological landscape of recent years, where the leading causes death are chronic diseases, reducing mortality differentials has become a more difficult problem in that it now calls for, in addition to government interventions, active engagement on the part of individuals in health-seeking behaviors.

Several recent studies in mortality point to the need to look with care, beyond infectious and chronic diseases, into socioeconomic differentials that arise in the process called 'aging', which they regard as the fundamental cause of diseases that people suffer from in later life. Clouston, Rubin, Phelan, and Link (2016) have pointed out that socioeconomic mortality differentials may widen in a stage of epidemiological transition where only a fraction of the population have access to the knowledge and resources needed to prevent and treat newly-emerged mortality risk factors. Vallin and Meslé have it that the epidemiological transition, having gone through its first and second stages (corresponding to infectious disease and cardiovascular disease, respectively), may well enter a third stage with the aging process taking the centerstage. This suggests that changes may well occur in the mechanisms

that give rise to between-group mortality differentials. The reason that the aging process is receiving increasing attention has to do with how as the process progresses, while the likelihood of death from one specific type of disease drops, the risk of competing diseases and disabilities—cardiovascular disease, cancer, functional loss, and cognitive disorder—increases.[6] This is to say that in an aging population, any therapeutic progress made against a specific disease may, as it gives way to another, end up with diminishing returns.[7] Given that when one's aging process begins and how fast it proceeds is not unrelated to one's socioeconomic circumstances, the question of how, with policy interventions, to delay the onset of aging and slow the process of aging presents itself as an emerging issue in the effort to address between-group mortality gaps.

6) Crimmins, E. M. (2015). Lifespan and healthspan: Past, present, and promise. Gerontologist, 55(6), 901–911; Goldman, D. P., Cutler, D., Rowe, J. W., Michaud, P. C., Sullivan, J., Peneva, D., & Olshansky, S. J. (2013). Substantial health and economic returns from delayed aging may warrant a new focus for medical research. Health Affairs, 32(10), 1698–1705.

7) Goldman, D. P., Cutler, D., Rowe, J. W., Michaud, P. C., Sullivan, J., Peneva, D., & Olshansky, S. J. (2013). Substantial health and economic returns from delayed aging may warrant a new focus for medical research. Health Affairs, 32(10), 1698–1705.