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Health inequalities in Korea: age- and sex-specific educational differences in the 10 leading causes of death

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Background An ideological climate has persisted in Korea that has discouraged public discussion of social inequalities. Thus studies on inequalities in mortality remain undeveloped. This study is to examine age- and cause-specific socioeconomic mortality differentials for both men and women representative of the Korean population.

Methods Using Korea's 1995 Census and 1995–2000 Death Certificate data, age-, sex-, and education-specific mortality rates were measured, after which education-specific rate ratios, and relative indices of inequality were calculated.

Results Graded educational differentials in mortality were observed among both sexes with higher mortality rates related to lower educational attainment in most causes of death. However, positive associations were identified between education levels and mortality rates with respect to ischaemic heart disease among older males and breast cancer among older females. The magnitude of educational inequality in mortality was not constant across causes and in some cases differed by sex.

Conclusions The changing relation between educational attainment and mortality rates from ischaemic heart disease and breast cancer likely reflects changes in the social distribution of risk factors that emerged in the process of Korea's rapid economic development. Studies on specific exposures over the life course influencing the occurrence of and survival after specific diseases would help provide a more complete understanding of patterns and trends in socioeconomic mortality differentials in Korea.

Keywords Adult, education, socioeconomic inequalities in economic development, Korea

Investigations into socioeconomic inequalities in mortality have been common in Great Britain,[1,2] the US,[3,4] and several European countries.[5,6] With the exception of two recent reports,[7,8] studies on socioeconomic mortality inequalities generally remain undeveloped in Korea and other parts of Asia. For example, death rates stratified by education and occupation have not been reported by the government, although the information required to calculate those rates is available in Korean Census and Death Certificate data. This paucity of studies may be attributed in part to the ideological climate. Public discussion of the existence of health and other inequalities has been difficult because South Korea's regimes have viewed such discussion as an attack upon their political legitimacy.

Korea has experienced dramatic socioeconomic change during the past half century. Following Japanese colonial occupation and World War II (1910–1945), the country was further devastated by the Korean War (1950–1953). After 1962, however, a series of economic development plans were implemented and Korea's rapid economic progress, often termed an 'economic miracle',[9] transformed the country from an agricultural to an industrialized society. With a growth rate approaching 10% a year, the gross national income per capita reached about USD 10 000 in 2000,[10]

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placing Korea 24th in the OECD member countries, ahead of Mexico and Hungary.[11] This represents a 100-fold increase in GDP per head in less than 40 years.[12] In 1960, life expectancy was 51.1 years for males and 53.7 years for females. In the year 2000 it was 71.0 for males and 78.6 for females; a dramatic improvement.[11] Thus, Korea exemplifies an industrialized country whose economic development and health improvement have been achieved in an extremely short period. Accordingly, various birth cohorts may have experienced rather different socioeconomic conditions over their lifetimes (e.g. in childhood). If past socioeconomic circumstances had an effect on present health and health inequalities, such a cohort effect might be evident with cohort age. For instance, Koreans with childhood experiences of war (e.g. those who were born between 1931 and 1950) may show different patterns of health and health inequalities from those whose childhood experiences were of rapid economic development (e.g. Koreans born 1951–1960). Although socioeconomic health inequalities between different age groups (birth cohorts) might simply reflect age of death differences in educational inequality rather than true cohort differences in the life course exposure, examining age-specific socioeconomic differences may suggest clues to processes that could affect different age groups and potentially different cohorts. This is the first Korean study to examine age- and cause-specific socioeconomic mortality differentials in a sample that includes both men and women representative of the Korean population.

Methods

Data sources and study subjects

Population denominators were calculated from the 1995 Census and the number and cause of death were obtained from 1995–2000 Death Certificate data. Educational levels of the Census were matched with those of Death Certificates using aggregate data because it was not possible to do individual matching for the follow-up of mortality. The study subjects consisted of 7 583 117 males and 7 594 258 females aged 35–64 at the time of 1995 Census. Adults aged 25–34 were excluded due to the small number who did not complete elementary education (0.3% for both sexes), which resulted in unstable numbers of cause-specific deaths in that group. Thus, this study includes cohorts born between 1931 and 1960. The Census data were collected 1–10 November 1995, and covered all residents of South Korea, including Korean military personnel (about 600 000 people) and the institutionalized, as well as foreigners. Foreign diplomatic officials, their families and entourage; foreign military personnel and their families; and Korean students and workers living abroad at the time of the Census were excluded. Education levels were categorized as No education, Elementary (6-year), Middle (3-year), High (3-year), College (3-year vocational college and 4-year university), and Graduate. Information was available on the highest level of education achieved, current attendance, suspension without graduation, and temporary suspension of education. The rate of refusal to answer education questions was low (0.04% for males and 0.02% for females).[13] Census data are electronically accessible through the Korean Statistical Information System.[13]

By law, all deaths of Koreans must be reported to the National Statistical Office within a month after their occurrence. Death during hospitalization or within 48 hours after discharge can be certified by the physician who examined the decedent. In other cases a death certificate is issued by two local community figures. The proportion of deaths certified by physicians was about 70–90% among decedents aged 35–64. For deaths not certified by physicians, any vague or missing item on the death certificate is clarified by the National Statistical Office via telephone. Levels of education categorized as No Education, Elementary, Middle, High, and College were determined by the highest level of education completed. The rate of failure to report the decedent's educational attainment on the death certificate was low (0.3% for males and 0.4% for females) among decedents aged 35–64 from November 1995 to December 2000. Death Certificate data are available to the public.

Analyses

Using causes of death coded in death certificates per the *International Classification of Disease, 10th Revision* (ICD-10), the 10 most common causes of death were identified for each sex. Age-, sex-, and education-specific mortality rates were calculated for these causes. Education-specific relative risks (RR) were computed using Poisson regression analyses with the data of sex-, 1-year age-, cause-, and education-specific numbers of population and death. With age calculated using 1 November 1995 as the reference date in the Census, age in Death Certificate data was determined by the same method using date of birth information rather than decedent age at the time of death. The results (i.e. mortality rates and RR) using date of birth information will be similar to those by mortality follow-up in cohort studies, provided that (1) Census and Death Certificate data cover all Koreans residing in Korea, (2) emigration and immigration numbers are relatively small compared with total population, and (3) misclassification bias for educational level is slight. Since the Census information at the Korean Statistical Information System[13] does not further categorize age-specific educational levels among the 60+ population, the 1995 Census 2% sample data provided by the National Statistical Office was used to estimate sex- and education-specific numbers for the group aged 55–64.

To take into account the different population distributions of the exposure with age group, a summary effect measure—the relative index of inequality (RII) was computed.[2,6,14–16] This measure regresses the midpoint of the cumulative proportion of the population in different educational groups on mortality. The parameter estimate from this regression is then divided by the average mortality resulting in a percentage mortality difference between the highest and lowest educational groups that can then be expressed like a rate ratio, so that a 50% difference is equal to a RII of 1.50.

Results

As presented in Tables 1 and 2, education levels for both sexes increased remarkably by age cohort, demonstrating the profound social changes that occurred in Korea in the last 50 years. While 42.5% of males aged 55–64 (born between 1931–1940) finished (34.0%) or failed to finish (8.5%) elementary education, only 8.4% of males aged 35–44 (born between 1951–1960) had only elementary school education. For females, the proportion of those having elementary education only reached 77.3% among those aged 55–64. However, the proportion decreased to 16.2%

Table 1 Cause-, age[a]- and education-specific mortality rates,[b] relative risks,[c] and relative indices of inequality (RII)[d] using Korean 1995 Census (November 1995) and Death Certificate data (November 1995–December 2000): male population

Age Group	**35–44**					**45–54**					**55–64**				
School graduated	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher
No. of population	25 471	283 190	607 468	1 667 677	1 097 403	50 328	439 907	513 662	812 076	473 315	136 307	548 215	295 652	370 019	262 427
% of population	0.7	7.7	16.5	45.3	29.8	2.2	19.2	22.4	35.5	20.7	8.5	34.0	18.3	22.9	16.3
Cause of death															
All causes															
No. of deaths	2567	21 548	19 368	23 272	7375	5758	36 428	23 970	27 335	9735	15 545	64 082	27 122	30 837	14 856
Mortality rate	1938.1	1463.3	613.1	268.4	129.2	2200.2	1592.5	897.4	647.3	395.5	2193.2	2247.9	1764.2	1602.7	1088.7
Relative risk	14.4	10.8	4.6	2.1	1.0	5.1	3.8	2.2	1.6	1.0	1.9	2.0	1.6	1.5	1.0
RII (95% CI)			20.2 (14.7, 27.9)					5.4 (4.6, 6.4)					2.0 (1.8, 2.3)		
Neoplasms (C00–D48)															
No. of deaths	333	3103	3394	5270	2154	1293	10 193	7468	9303	3817	5046	23 320	10 083	11 772	6096
Mortality rate	251.4	210.7	107.4	60.8	37.7	494.1	445.6	279.6	220.3	155.1	711.9	818.0	655.9	611.8	446.7
Relative risk	5.9	4.8	2.6	1.6	1.0	2.7	2.6	1.8	1.4	1.0	1.4	1.7	1.5	1.4	1.0
RII (95% CI)			6.4 (5.1, 8.1)					3.2 (2.8, 3.6)					1.7 (1.5, 1.9)		
Stomach cancer (C16)															
No. of deaths	80	553	662	1048	426	282	1976	1413	1763	681	1202	5247	2039	2298	1215
Mortality rate	60.4	37.6	21.0	12.1	7.5	107.8	86.4	52.9	41.7	27.7	169.6	184.1	132.6	119.4	89.0
Relative risk	7.3	4.5	2.6	1.6	1.0	3.3	2.8	1.9	1.5	1.0	1.7	2.0	1.5	1.4	1.0
RII (95% CI)			6.1 (4.7, 7.9)					3.5 (3.1–4.0)					2.1 (1.8, 2.4)		
Liver cancer (C22)															
No. of deaths	119	1237	1365	1970	709	396	3387	2531	3204	1293	1001	4872	2184	2694	1443
Mortality rate	89.8	84.0	43.2	22.7	12.4	151.3	148.1	94.8	75.9	52.5	141.2	170.9	142.1	140.0	105.7
Relative risk	6.3	5.7	3.1	1.8	1.0	2.6	2.6	1.8	1.5	1.0	1.3	1.6	1.3	1.3	1.0
RII (95% CI)			8.0 (6.3, 10.0)					3.2 (2.7, 3.7)					1.5 (1.3, 1.7)		
Lung cancer (C34)															
No. of deaths	43	381	360	546	230	251	1805	1207	1354	554	1277	5880	2394	2545	1084
Mortality rate	32.5	25.9	11.4	6.3	4.0	95.9	78.9	45.2	32.1	22.5	180.2	206.3	155.7	132.3	79.4
Relative risk	6.8	5.2	2.5	1.5	1.0	3.5	3.1	1.9	1.5	1.0	2.0	2.5	2.0	1.7	1.0
RII (95% CI)			7.3 (5.3, 10.0)					4.2 (3.6–4.9)					2.2 (1.8, 2.7)		
Circulatory diseases (I00–I99)															
No. of deaths	378	2827	2704	3543	1171	1002	6156	4222	5376	2084	3386	13 686	6291	7888	3880
Mortality rate	285.4	192.0	85.6	40.9	20.5	382.9	269.1	158.1	127.3	84.7	477.7	480.1	409.2	410.0	284.3
Relative risk	12.9	8.5	3.9	2.0	1.0	4.0	2.9	1.8	1.5	1.0	1.5	1.6	1.4	1.5	1.0
RII (95% CI)			14.3 (10.4, 19.7)					3.8 (3.3, 4.6)					1.5 (1.3, 1.7)		
Cerebro-vascular accidents (I60–I69)															
No. of deaths	180	1233	1172	1570	484	531	3197	2170	2676	979	2035	8201	3858	4589	2102
Mortality rate	135.9	83.7	37.1	18.1	8.5	202.9	139.8	81.2	63.4	39.8	287.1	287.7	250.9	238.5	154.0
Relative risk	14.6	8.8	4.0	2.1	1.0	4.4	3.2	2.0	1.6	1.0	1.6	1.7	1.6	1.6	1.0
RII (95% CI)			14.6 (10.7, 20.1)					4.2 (3.5, 5.1)					1.6 (1.4, 1.9)		
Ischaemic heart diseases (I20–I25)															
No. of deaths	53	519	598	916	313	165	1041	891	1386	636	369	1933	1075	1655	1022
Mortality rate	40.0	35.2	18.9	10.6	5.5	63.0	45.5	33.4	32.8	25.8	52.1	67.8	69.9	86.0	74.9
Relative risk	6.6	5.7	3.2	1.9	1.0	2.1	1.6	1.3	1.3	1.0	0.6	0.8	0.9	1.2	1.0
RII (95% CI)			7.6 (5.7, 10.2)					1.8 (1.5–2.1)					0.6 (0.5, 0.7)		

Table 1 Continued

Age Group	35–44					45–54					55–64				
School graduated	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher
No. of population	25 471	283 190	607 468	1 667 677	1 097 403	50 328	439 907	513 662	812 076	473 315	136 307	548 215	295 652	370 019	262 427
% of population	0.7	7.7	16.5	45.3	29.8	2.2	19.2	22.4	35.5	20.7	8.5	34.0	18.3	22.9	16.3
Cause of death (cont)															
External causes (S00-Y98)															
No. of deaths	595	6484	6250	7480	2264	1045	7083	4486	4549	1318	1716	7359	2803	2813	1071
Mortality rate	449.2	440.3	197.9	86.3	39.7	399.3	309.6	167.9	107.7	53.6	242.1	258.1	182.3	146.2	78.5
Relative risk	11.7	11.5	5.1	2.2	1.0	7.4	5.7	3.1	2.0	1.0	3.0	3.2	2.3	1.9	1.0
RII (95% CI)			21.0 (15.9, 27.6)					8.6 (7.5, 9.9)					3.5 (2.9, 4.1)		
Transport accidents (V01–V99)															
No. of deaths	204	2478	2522	3327	1106	393	3030	1900	1947	575	666	3448	1257	1231	468
Mortality rate	154.0	168.3	79.8	38.4	19.4	150.2	132.5	71.1	46.1	23.4	94.0	121.0	81.8	64.0	34.3
Relative risk	8.2	9.1	4.2	2.0	1.0	6.3	5.6	3.0	2.0	1.0	2.7	3.5	2.3	1.9	1.0
RII (95% CI)			14.6 (11.3, 18.9)					8.1 (6.9, 9.4)					3.5 (2.8, 4.4)		
Intentional self-harm (X60–X84)															
No. of deaths	147	1735	1517	1687	504	234	1447	960	1058	354	381	1317	545	632	244
Mortality rate	111.0	117.8	48.0	19.5	8.8	89.4	63.3	35.9	25.1	14.4	53.8	46.2	35.4	32.8	17.9
Relative risk	13.0	13.9	5.6	2.2	1.0	6.2	4.4	2.5	1.7	1.0	3.0	2.6	2.0	1.9	1.0
RII (95% CI)			28.1 (19.8, 39.8)					6.6 (5.4, 8.1)					2.8 (2.3, 3.4)		
Other causes[e]															
No. of deaths	1261	9134	7020	6979	1786	2418	12 996	7794	8107	2516	5397	19 717	7945	8364	3809
Mortality rate	952.1	620.3	222.2	80.5	31.3	923.9	568.1	291.8	192.0	102.2	761.4	691.7	516.8	434.7	279.1
Relative risk	29.1	18.8	6.8	2.5	1.0	8.5	5.4	2.8	1.9	1.0	2.5	2.4	1.8	1.6	1.0
RII (95% CI)			48.2 (31.9, 72.8)					8.8 (7.1, 10.8)					2.7 (2.3, 3.1)		
Liver diseases (K70–K76)															
No. of deaths	460	4245	3307	3014	701	931	5783	3317	3223	941	1427	5774	2206	2029	816
Mortality rate	347.3	288.3	104.7	34.8	12.3	355.7	252.8	124.2	76.3	38.2	201.3	202.5	143.5	105.5	59.8
Relative risk	26.8	22.0	8.2	2.8	1.0	9.1	6.5	3.2	2.0	1.0	3.4	3.4	2.4	1.8	1.0
RII (95% CI)			57.4 (39.0, 84.6)					10.9 (9.0, 13.3)					4.0 (3.3, 4.7)		
Diabetes mellitus (E10–E14)															
No. of deaths	93	698	504	530	113	218	1411	924	1025	334	617	2840	1416	1885	884
Mortality rate	70.2	47.4	16.0	6.1	2.0	83.3	61.7	34.6	24.3	13.6	87.0	99.6	92.1	98.0	64.8
Relative risk	32.2	21.4	7.4	3.0	1.0	5.3	4.2	2.5	1.8	1.0	1.2	1.4	1.4	1.5	1.0
RII (95% CI)			49.3 (31.2, 77.9)					5.7 (4.5, 7.1)					1.2 (1.0, 1.5)		
Tuberculosis (A15–A19)															
No. of deaths	115	666	433	378	96	202	843	511	502	108	414	1345	488	503	176
Mortality rate	86.8	45.2	13.7	4.4	1.7	77.2	36.9	19.1	11.9	4.4	58.4	47.2	31.7	26.1	12.9
Relative risk	49.1	25.4	7.8	2.6	1.0	16.8	8.2	4.3	2.7	1.0	4.0	3.5	2.4	2.0	1.0
RII (95% CI)			94.6 (52.8, 169.3)					13.1 (9.4, 18.2)					4.1 (3.3, 5.0)		

[a] Decedent's age was calculated as the numbers of year between the day of birth on Death Certificate data and 1 November 1995, the time of the Census.

[b] Mortality rates = (No. of deaths × 100 000) ÷ No. of population ÷ 5.2 years.

[c] Relative risks were computed using Poisson regression analyses with the data of sex-, cause-, 1-year age-, education-specific number of deaths and population. 'College or higher' groups was the referent (1.0).

[d] Relative indices of inequalities were computed using Poisson regression analyses with the data of sex-, 1-year age-, cause-, education-specific number of deaths, and population. This index is the relative rate of mortality for the hypothetically lowest educated compared with the hypothetically highest educated person in the population, assuming a linear association between education and mortality risk.

[e] Except for neoplasms, circulatory diseases, and external causes of death, all other ICD-10 codes were categorized into 'Other causes'.

Table 2 Cause-, age[a]- and education-specific mortality rates,[b] relative risks,[c] and relative indices of inequality (RII)[d] using Korean 1995 Census (November 1995) and Death Certificate data (November 1995–December 2000): female population

Age Group	**35–44**					**45–54**					**55–64**				
School graduated	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher
No. of population	38 139	530 758	981 355	1 506 417	464 536	155 384	876 202	569 706	481 219	154 626	533 503	885 505	217 078	153 476	46 354
% of population	1.1	15.1	27.9	42.8	13.2	6.9	39.2	25.5	21.5	6.9	29.1	48.2	11.8	8.4	2.5
Cause of death															
All causes															
No. of deaths	1256	7622	6566	7429	1605	4600	17 564	7131	5571	1337	23 665	36 260	6755	4584	1033
Mortality rate	633.3	276.2	128.7	94.8	66.4	569.3	385.5	240.7	222.6	166.3	853.0	787.5	598.4	574.4	428.6
Relative risk	9.0	4.0	1.9	1.4	1.0	2.9	2.1	1.4	1.3	1.0	1.7	1.7	1.4	1.3	1.0
RII (95% CI)			5.5 (4.1, 7.4)					2.7 (2.4, 3.1)					1.3 (1.1, 1.5)		
Neoplasms (C00–D48)															
No. of deaths	273	2351	2387	3179	845	1359	6410	2970	2566	749	6704	12 054	2428	1854	458
Mortality rate	137.7	85.2	46.8	40.6	35.0	168.2	140.7	100.3	102.5	93.2	241.7	261.8	215.1	232.3	190.0
Relative risk	3.6	2.2	1.3	1.2	1.0	1.5	1.4	1.1	1.1	1.0	1.1	1.3	1.1	1.2	1.0
RII (95% CI)			2.6 (2.1, 3.2)					1.6 (1.4, 1.8)					0.9 (0.8, 1.1)		
Stomach cancer (C16)															
No. of deaths	72	481	455	683	177	256	1170	489	381	123	1552	2420	347	224	39
Mortality rate	36.3	17.4	8.9	8.7	7.3	31.7	25.7	16.5	15.2	15.3	55.9	52.6	30.7	28.1	16.2
Relative risk	4.7	2.3	1.2	1.2	1.0	1.8	1.6	1.1	1.0	1.0	3.1	3.2	1.9	1.7	1.0
RII (95% CI)			2.6 (1.9, 3.5)					2.1 (1.8, 2.5)					1.7 (1.4, 2.1)		
Liver cancer (C22)															
No. of deaths	35	278	272	265	49	220	1028	388	312	61	1023	1742	353	276	68
Mortality rate	17.6	10.1	5.3	3.4	2.0	27.2	22.6	13.1	12.5	7.6	36.9	37.8	31.3	34.6	28.2
Relative risk	7.5	4.4	2.5	1.7	1.0	3.0	2.7	1.7	1.6	1.0	1.1	1.3	1.1	1.2	1.0
RII (95% CI)			5.3 (4.0, 7.1)					2.7 (2.2, 3.3)					1.0 (0.9, 1.2)		
Lung cancer (C34)															
No. of deaths	17	193	196	270	72	153	658	306	258	77	922	1521	305	199	61
Mortality rate	8.6	7.0	3.8	3.4	3.0	18.9	14.4	10.3	10.3	9.6	33.2	33.0	27.0	24.9	25.3
Relative risk	2.6	2.1	1.2	1.1	1.0	1.6	1.3	1.0	1.1	1.0	1.1	1.2	1.0	0.9	1.0
RII (95% CI)			2.3 (1.7, 3.1)					1.5 (1.2, 1.9)					1.1 (0.9, 1.3)		
Breast cancer (C50)															
No. of deaths	22	268	334	539	173	82	557	337	364	123	178	514	147	163	51
Mortality rate	11.1	9.7	6.5	6.9	7.2	10.1	12.2	11.4	14.5	15.3	6.4	11.2	13.0	20.4	21.2
Relative risk	1.4	1.2	0.9	1.0	1.0	0.6	0.8	0.7	1.0	1.0	0.3	0.4	0.6	0.9	1.0
RII (95% CI)			1.2 (0.9, 1.5)					0.7 (0.6, 0.8)					0.3 (0.2, 0.4)		
Circulatory diseases (I00–I99)															
No. of deaths	277	1379	1093	1037	144	1206	4544	1685	1127	168	7987	11 819	2050	1313	233
Mortality rate	139.7	50.0	21.4	13.2	6.0	149.3	99.7	56.9	45.0	20.9	287.9	256.7	181.6	164.5	96.7
Relative risk	20.4	7.4	3.4	2.2	1.0	5.9	4.3	2.7	2.2	1.0	2.4	2.4	1.9	1.7	1.0
RII (95% CI)			9.9 (6.8, 14.5)					4.0 (3.4, 4.7)					1.4 (1.2, 1.7)		
Cerebro-vascular accidents (I60–I69)															
No. of deaths	120	753	621	632	83	712	2857	1051	692	98	5144	7567	1289	794	146
Mortality rate	60.5	27.3	12.2	8.1	3.4	88.1	62.7	35.5	27.7	12.2	185.4	164.3	114.2	99.5	60.6
Relative risk	14.7	6.8	3.3	2.3	1.0	5.9	4.6	2.8	2.3	1.0	2.4	2.4	1.9	1.6	1.0
RII (95% CI)			7.4 (5.4, 10.4)					3.9 (3.2, 4.7)					1.5 (1.3, 1.8)		

Table 2 Continued

Age Group	35–44					45–54					55–64				
School graduated	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher	No education	Elementary	Middle	High	College or higher
No. of population	38 139	530 758	981 355	1 506 417	464 536	155 384	876 202	569 706	481 219	154 626	533 503	885 505	217 078	153 476	46 354
% of population	1.1	15.1	27.9	42.8	13.2	6.9	39.2	25.5	21.5	6.9	29.1	48.2	11.8	8.4	2.5
Cause of death (cont)															
Ischaemic heart diseases (I20–I25)															
No. of deaths	29	192	132	124	14	144	485	215	150	31	820	1423	312	263	36
Mortality rate	14.6	7.0	2.6	1.6	0.6	17.8	10.6	7.3	6.0	3.9	29.6	30.9	27.6	33.0	14.9
Relative risk	22.7	10.9	4.3	2.7	1.0	3.9	2.5	1.8	1.6	1.0	1.5	1.8	1.8	2.0	1.0
RII (95% CI)			12.8 (7.0, 23.4)					3.0 (2.4, 3.8)					0.8 (0.6, 0.9)		
External causes (S00–Y98)															
No. of deaths	225	1905	1704	1824	359	606	2503	912	673	161	1939	3036	536	276	78
Mortality rate	113.5	69.0	33.4	23.3	14.9	75.0	54.9	30.8	26.9	20.0	69.9	65.9	47.5	34.6	32.4
Relative risk	8.1	4.9	2.3	1.6	1.0	3.5	2.7	1.5	1.3	1.0	2.1	2.1	1.5	1.1	1.0
RII (95% CI)			6.4 (5.1, 8.2)					3.7 (3.2, 4.2)					1.7 (1.4, 2.1)		
Transport accidents (V01–V99)															
No. of deaths	72	735	660	692	141	268	1254	440	299	69	946	1707	280	141	33
Mortality rate	36.3	26.6	12.9	8.8	5.8	33.2	27.5	14.9	11.9	8.6	34.1	37.1	24.8	17.7	13.7
Relative risk	6.3	4.6	2.2	1.5	1.0	3.5	3.0	1.7	1.4	1.0	2.5	2.8	1.9	1.3	1.0
RII (95% CI)			6.0 (4.7, 7.6)					3.7 (3.1, 4.5)					1.5 (1.2, 2.0)		
Intentional self-harm (X60–X84)															
No. of deaths	67	559	484	541	116	147	548	212	165	49	361	505	100	56	16
Mortality rate	33.8	20.3	9.5	6.9	4.8	18.2	12.0	7.2	6.6	6.1	13.0	11.0	8.9	7.0	6.6
Relative risk	8.0	4.7	2.1	1.5	1.0	3.0	2.0	1.2	1.1	1.0	1.9	1.7	1.3	1.1	1.0
RII (95% CI)			6.4 (4.7, 8.9)					3.4 (2.7, 4.3)					1.8 (1.4, 2.3)		
Other causes[e]															
No. of deaths	481	1987	1382	1389	257	1429	4107	1564	1205	259	7035	9351	1741	1141	264
Mortality rate	242.5	72.0	27.1	17.7	10.6	176.9	90.1	52.8	48.2	32.2	253.6	203.1	154.2	143.0	109.5
Relative risk	21.9	6.5	2.5	1.7	1.0	4.7	2.6	1.6	1.5	1.0	1.9	1.7	1.4	1.3	1.0
RII (95% CI)			12.1 (7.5, 19.5)					3.9 (3.2, 4.8)					1.6 (1.4, 1.8)		
Liver diseases (K70–K76)															
No. of deaths	75	468	327	308	38	317	1094	417	317	61	888	1525	322	235	48
Mortality rate	37.8	17.0	6.4	3.9	1.6	39.2	24.0	14.1	12.7	7.6	32.0	33.1	28.5	29.4	19.9
Relative risk	21.1	9.6	3.8	2.5	1.0	4.4	2.9	1.8	1.7	1.0	1.5	1.6	1.3	1.4	1.0
RII (95% CI)			12.0 (7.9, 18.3)					3.4 (2.7, 4.4)					1.1 (0.9, 1.4)		
Diabetes mellitus (E10–E14)															
No. of deaths	39	211	117	107	10	274	774	262	168	26	1812	2629	485	275	56
Mortality rate	19.7	7.6	2.3	1.4	0.4	33.9	17.0	8.8	6.7	3.2	65.3	57.1	43.0	34.5	23.2
Relative risk	44.1	17.3	5.4	3.3	1.0	7.8	4.4	2.6	2.1	1.0	2.1	2.1	1.8	1.4	1.0
RII (95% CI)			23.4 (12.6, 43.7)					5.3 (3.9, 7.1)					1.4 (1.2, 1.7)		

[a] Decedent's age was calculated as the number of years between the day of birth on Death Certificate data and 1 November 1995, the time of the Census.

[b] Mortality rates = (No. of deaths × 100 000) ÷ No. of population ÷ 5.2 years.

[c] Relative risks were computed using Poisson regression analyses with the data of sex-, cause-, 1-year age-, education-specific number of deaths, and population. 'College or higher' groups was the referent (1.0).

[d] Relative indices of inequalities were computed using Poisson regression analyses with the data of sex-, 1-year age-, cause-, education-specific number of deaths, and population. This index is the relative rate of mortality for the hypothetically lowest educated compared with the hypothetically highest educated person in the population, assuming a linear association between education and mortality risk.

[e] Except for neoplasms, circulatory diseases, and external causes of death, all other ICD-10 codes were categorized into 'Other causes'.

among females aged 35–44. These findings show that males are still more highly educated than females, and that relative educational inequality has widened somewhat over time.

The 10 leading causes of death differed by sex. These nine causes were the most common in both sexes: cerebrovascular accidents (CVA), liver disease, liver cancer, transport accidents, stomach cancer, lung cancer, diabetes mellitus, ischaemic heart disease (IHD), and intentional self-harm. In addition, tuberculosis was added to the 10 common causes for males and breast cancer for females. These causes of death accounted for 64.4% of the male and 57.6% of the female deaths. While in females the leading cause was CVA, followed by stomach cancer, transport accidents, and diabetes mellitus, the most common cause in males was liver diseases followed by CVA, liver cancer, and transport accidents. The remaining causes of death were chronic lower respiratory diseases, pneumonia, and colon cancer in men and uterine cervix cancer, colon cancer, and chronic lower respiratory diseases in women.

Tables 1 and 2 show that for both sexes in all age groups, all-cause mortality increased with decreasing education. There were very large absolute and relative educational differences in mortality among younger men aged 35–44 (1809 deaths per 100 000 and RII = 20.2, 95% CI: 14.7, 27.9), with relative inequality among educational groups declining with age. For women, absolute and relative educational differences were generally much smaller with the largest also being observed among younger women aged 35–44 (567 deaths per 100 000; and RII = 5.5, 95% CI: 4.1, 7.4).

In regard to specific causes of death however, some heterogeneity of strength and direction of educational differences in RII were found. For instance, among males, mortality decreased in a graded fashion as education increased in all age groups for liver disease, cancers, CVA, transport accidents, self-harm, diabetes, and tuberculosis. On the other hand, among the oldest men aged 55–64, less education was associated with a lower IHD mortality rate. The opposite pattern was seen in younger men, so that IHD decreased with educational attainment among males aged 35–44 and 45–54.

For females in all age groups, graded associations between higher education and lower mortality were observed for stomach cancer, CVA, transport accidents, intentional self-harm, and diabetes mellitus. Breast cancer mortality rates showed a positive relationship with education level among females aged 45–54 and 55–64. However, among females aged 35–44, about 20% more elementary school graduates and 40% more of the ‘No Education’ group died from breast cancer than those who completed higher education. In contrast to males, among females aged 55–64 there was no relationship between education level and IHD mortality. Similarly, among this older group of women aged 55–64 there was no association between education and liver cancer, lung cancer, and liver disease mortality. It is also noteworthy that educational inequality in mortality was uniformly greater among younger age groups.

Discussion

This study revealed educational mortality differentials among both sexes in Korea that in some cases were very strong. However, the strength of the association varied somewhat by age and cause and may, to some extent, reflect cohort differences in life course exposures—particularly for IHD and breast cancer—that may be associated with Korea’s rapid economic development. This investigation is the first to report age- and cause-specific socioeconomic mortality differentials representative of the adult population and importantly, representative of the female population in Korea. Song and Byeon found mortality gradients according to income levels in Korean male civil servants.[7] Son *et al.* examined occupational and educational mortality differentials but did not include the unemployed or housewives.[8]

Since this study was not based on record linkage, where information from the death certificate could be linked to information from the census (thus eliminating numerator/denominator bias), it is possible that artefacts may explain some of the observed educational mortality gradients. Because the relative size of education levels has changed dramatically over time in Korea, with the lowest levels of education becoming much less common, educational mortality differentials might be exaggerated when a broader age range (e.g. 35–64) was used. An older population would show a greater probability of dying among the less educated, whereas the younger population would contribute to a low probability of dying among the more educated. To reduce the possibility of this type of induced artefact, 10-year age groups were used.

Emigration and immigration may also contribute to overstatement of educational mortality differences. Citizens who emigrated from Korea from November 1995 to December 2000 were likely to be more educated, thus increasing the denominator of the more educated. Their deaths, however, would not contribute to the numerator of the more educated because they would not be reported to the National Statistical Office of Korea. Only 61 351 people (0.15% of the Korean population) emigrated during 1996–2000.[17] In addition, foreigners residing in Korea were included in the Census, and were likely to raise the denominator of the more educated. However, foreigners aged 35+ numbered only 14 247, accounting for 0.08% of the same-aged Korean population.[13] Therefore artefacts from these causes appear slight.

In contrast to emigrants and foreigners, students studying and workers living abroad might produce diluted educational mortality differentials. Because their deaths during the 5.2-year study period might be reported to the National Statistical Office, they could raise the numerator of the more educated. To reduce such a possibility, this study did not include groups aged less than 35 who were more likely to go abroad to study or work.

The role of artefacts in the explanation of our results does not appear to be very plausible given the heterogeneity in the direction of differentials, the highest rate being found sometimes in low education level (e.g. stomach cancer) and sometimes in high education level (e.g. breast cancer). Previous studies have found that education levels tend to be over-reported rather than underreported.[18,19] Hence, education levels of the Census might be more inflated than those of Death Certificate data, thus exaggerating educational mortality differentials. However, this seems unlikely because the 1995 Census questionnaire required more detailed information on education than called for by death certificate questionnaires. Sorlie and Johnson found a tendency for the decedent’s education to be reported at a higher level on the death certificate than in a household survey.[20]

The reliability of responses provided by the Korean Census and Death Certificate data requires further investigation.

The contribution of natural/social selection to the generation of socioeconomic health inequalities has been disputed.[21–25] Health selection is unlikely as a method of explaining the observed educational mortality differentials because educational attainment is less subject to negative adult health selection.[26] Causal interpretations for health inequalities according to educational attainment can be interpreted via various mechanisms, including early-life conditions,[16,26,27] acquisition of health promoting/damaging behaviours,[28–31] development of time preferences favourable to health maintenance,[32] optimization of health care usage,[30,31] and development of positive psychosocial attributes.[30,32] However, education can have specific meanings in specific contexts and thus peculiar effects on a society such as Korea, in which socioeconomic advances have occurred at a remarkably rapid pace. The general consensus is that education played an instrumental role in Korea's miraculous industrialization and economic growth.[33–35] The economy has become primarily dependent on the accelerated growth in labour-intensive, high skill export industries which demand a well-educated workforce. For the same reason, higher education in Korea thus guarantees higher material and social well-being. Thus, education has been the first priority for all parents, who subsequently are willing to sacrifice great amounts of money and time for their children's education. Under such circumstances, educational levels can represent the best way to advance one's socioeconomic position.

Furthermore, given that rapid economic growth would bring about rapid growth of health-related knowledge and healthcare technology, education might well assure the cognitive ability to adopt health-promoting lifestyles and practices quickly. In Korea, rapidly declining fertility rates may also contribute to educational mortality differentials. Educated women might participate more in the national family planning campaign promoting smaller families, which started with governmental economic development plans and has proven to be very successful.[36] Higher per child expenditures for education could be converted to a consequent increase in the quantity and quality of schooling and thus generate intergenerational (from mothers to children) educational inequalities.

Based on the results of RII, relative levels of all-cause mortality inequalities were smaller in females than in males. In other countries, women's socioeconomic all-cause mortality differences have appeared to be smaller than those of men.[37,38] The idea that gender differences in socioeconomic health inequalities depended on the measure of the inequality used has also been investigated.[37,39] In Korea, different socioeconomic measures capturing other dimensions of social inequality among women may produce similar or even greater social mortality gradients than those in men.

Compared with a previous study in six European countries,[40] educational mortality differences according to the broad causes of death showed similar patterns in Korea. Compared with all causes mortality inequalities measured by RII, relatively small mortality inequalities in neoplasms and greater mortality inequality in 'other causes' were found among males, while female mortality inequalities in circulatory diseases were greater than in all causes. In contrast to the previous study,[40] however, negative relationships between education levels and mortality rates from external causes of death persisted in this study.

In this study IHD presented a cross-over pattern of educational mortality differences according to age in males, such that higher education was associated with lower IHD risk among the youngest men and women. This pattern reduced with age and then reversed so that among those aged 55–64 higher IHD mortality was associated with higher education. This pattern was less clear among women although there was some evidence from the RII that a similar situation occurred among the oldest women. A previous study found no relation between income and mortality from coronary heart disease among Korean male civil servants aged 30–64,[7] but this could have resulted from collapsing age groups. Kunst *et al.* observed no or even a positive association between social class and IHD mortality in males in several southern European countries where IHD mortality is traditionally low.[41] Meanwhile, studies in the UK[42] and the US[43] reported that the relation between socioeconomic position and coronary heart disease mortality has changed from positive (increasing mortality with higher social status) to negative among males, but remained negative among females. Davey Smith suggested that these findings were attributable to misclassification of cause of death combined with the early 20th century's prevalent views that IHD is a disease of the affluent classes.[44] While this may be true for early 20th century Britain, it may not hold for late 20th century Korea, as it is unlikely to produce that kind of misclassification of IHD exclusively for one age group (55–64 in this study). Thus, the observed reversed socioeconomic pattern with age may be real. The fact that socioeconomic gradients for IHD reversed in men by birth cohort but not in women may reflect the timing and gender distribution of the risk factors for IHD as they move through the rapid economic development of Korean society.

Korean male civil servants aged 30–64 with higher socioeconomic position showed higher levels of serum cholesterol and obesity, and similar levels of alcohol consumption than those of lower socioeconomic position.[7] Because this study found that lung cancer, liver disease, and CVA mortality decreased with educational attainment among all age groups, smoking, alcohol consumption, and hypertension (especially for haemorrhagic stroke) may not contribute to the reversing pattern. Considering that about 60% of females aged 35–64 in 1995 did not participate in the labour market,[13] the changing relationship among males may reflect changes in job-related risk factors (e.g. sedentary lifestyle), sex differences in social distribution of dietary fat intake, and metabolic responses to dietary fat[45] as ways of understanding sex differences in the social distribution of IHD. In addition, given that body mass index and triglyceride levels were dependent on childhood social class while smoking behaviour, alcohol consumption, and hypertension were more strongly associated with current social class,[46] a contribution of childhood experience to the reversing pattern in men is worth investigating.

This study found a positive association between education level and breast cancer mortality among females aged 45–64, but identified higher breast cancer mortality among females aged 35–44 with an educational attainment of elementary school or less. Several reports have suggested that the social distribution of breast cancer in terms of both incidence and survival may be changing, so that the social differences are attenuating or perhaps even reversing.[47–49]

The heterogeneity in relationships between cause of death and socioeconomic position suggests that any single factor (e.g. differences in general susceptibility[50,51] or smoking) cannot account for these associations. Studies on specific exposures over the life course which influence the occurrence of and survival after specific diseases would provide better understanding of this heterogeneity. Birth cohort analysis rather than collapsing broad age groups may give more information on socioeconomic health inequalities in a society like Korea with a rapid socioeconomic transition. Since it is uncertain whether the IHD and breast cancer mortality distributions at different socioeconomic stages and younger ages in this study would persist, follow-up studies for different age groups are needed.

KEY MESSAGES

- Age- and cause-specific educational mortality differentials were examined for both men and women in Korea where studies on socioeconomic health inequalities remained undeveloped.
- Graded educational differentials in mortality were observed among both sexes with higher mortality rates related to lower educational attainment in most causes of death.
- Positive associations were identified between education levels and mortality rates with respect to ischaemic heart disease among older males and breast cancer among older females, likely reflecting changes in the social distribution of risk factors that emerged in the process of Korea's rapid economic development.

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Commentary: Why the educational effect is so strong in differentials of mortality in Korea?

Mia Son

This paper presents educational mortality differentials in Korea. In particular, this study stresses that amongst young people the poorly educated have a higher mortality than the well-educated group.[1] This study agrees with findings from previous studies: there is a strong inverse relationship between education and all-cause as well as specific causes of mortality in Korea and education contributes to the wider inequalities in health in Korea.[2,3]

The authors' question why little research on inequality in health has been carried out in Korea. The authors believe the reason is 'the ideological climate', that is, 'South Korea's regimes have viewed such discussion as an attack upon their political legitimacy.' However, this situation occurs not only in Korea.

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