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ORIGINAL RESEARCH

Disparities in Mortality and Cardiovascular Events by Income and Blood Pressure Levels Among Patients With Hypertension in South Korea

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BACKGROUND: Socioeconomic status is associated with differences in risk factors of cardiovascular disease and increased risks of cardiovascular disease and mortality. However, it is unclear whether an association exists between cardiovascular disease and income, a common measure of socioeconomic status, among patients with hypertension.

METHODS AND RESULTS: This population-based longitudinal study comprised 479 359 patients aged ≥19 years diagnosed with essential hypertension. Participants were categorized by income and blood pressure levels. Primary end point was all-cause and cardiovascular mortality and secondary end points were cardiovascular events, a composite of cardiovascular death, myocardial infarction, and stroke. Low income was significantly associated with high all-cause (hazard ratio [HR], 1.26; 95% CI, 1.23–1.29, lowest versus highest income) and cardiovascular mortality (HR, 1.31; 95% CI, 1.25–1.38) as well as cardiovascular events (HR, 1.07; 95% CI, 1.05–1.10) in patients with hypertension after adjusting for age, sex, systolic blood pressure, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and the use of aspirin or statins. In each blood pressure category, low-income levels were associated with high all-cause and cardiovascular mortality and cardiovascular events. The excess risks of all-cause and cardiovascular mortality and cardiovascular events associated with uncontrolled blood pressure were more prominent in the lowest income group.

CONCLUSIONS: Low income and uncontrolled blood pressure are associated with increased all-cause and cardiovascular mortality and cardiovascular events in patients with hypertension. These findings suggest that income is an important aspect of social determinants of health that has an impact on cardiovascular outcomes in the care of hypertension.

Key Words: blood pressure ■ cardiovascular diseases ■ health status disparities ■ hypertension ■ income ■ mortality

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CLINICAL PERSPECTIVE

What Is New?

- Among individuals with similar blood pressure levels, low-income levels were associated with high all-cause mortality, cardiovascular mortality, and cardiovascular event rates.
- Low income and uncontrolled blood pressure were associated with increased all-cause mortality, cardiovascular mortality, and cardiovascular events in patients with hypertension.

What Are the Clinical Implications?

- To our knowledge, this is the first study to examine the combined effects of income and blood pressure on all-cause and cardiovascular mortality and cardiovascular events in patients with hypertension.
- Income is an important aspect of social determinants of health that has an impact on cardiovascular outcomes in the care of hypertension.

Nonstandard Abbreviations and Acronyms

NHIS	National Health Insurance Service

Socioeconomic status (SES) is an important determinant of the likelihood that individuals and populations are exposed to environmental and other health risk factors. SES is closely related to cardiovascular disease (CVD) risk factors, morbidity, and mortality.[1–5] Currently, the CVD incidence is the highest among individuals with the lowest SES. Low SES is linked to the least favorable health behavioral characteristics[6–9] and is also associated with the worst prognosis after cardiac episodes.[6–9] Despite sharp declines in CVD mortality during the past 30 years, these benefits have not occurred equally across all populations in society. The most striking improvements in cardiovascular health have benefited wealthy, highly educated individuals, whereas progress among individuals with low SES has lagged, and the gap between high-SES and low-SES populations is widening.[10]

A recent meta-analysis demonstrated an inverse association between income as a key indicator of SES and CVD and cardiovascular-related deaths.[11] However, few studies have focused on the relationships among income, mortality, and cardiovascular outcomes in patients with hypertension. Assessing the data from a real-world electronic nationwide longitudinal health database would not only help better characterize the links among income, mortality, and CVD but also help guide efforts to reduce CVD burden through health service development and primary or secondary prevention. This study was conducted to evaluate the effects of income and blood pressure (BP) levels and their combined effects on mortality and cardiovascular events in more than 10 years of follow-up in 1 554 406 Korean patients with hypertension using a large nationwide representative data set.

METHODS

Data Source

This study involved the analysis of data from the National Health Insurance Service (NHIS)–National Health examinee database, which includes the data of all individuals who underwent National Health Examinations sponsored by the NHIS in South Korea. NHIS is a single insurance provider in Korea and covers 97% of the Korean population, whereas the remaining 3% are covered by the medical aid program. The NHIS claims database includes data of demographic characteristics, diagnoses, prescriptions, health screening examinations (eg, health questionnaires and laboratory tests), and death. Details on the data source have been described previously.[12] All diagnoses are recorded in the NHIS database using *International Classification of Diseases, Tenth Revision* (*ICD-10*) codes. The study was approved by the Institutional Review Board of Kangbuk Samsung Hospital (KBSMC 2019-12-022). The NHIS provided the anonymized data set to the researchers, and the requirement for informed consent was waived.

Study Population

The cohort included 1 554 406 participants aged ≥19 years who underwent health screening at least twice within 4 years between 2002 and 2011. Among these participants, we included 612 399 individuals who were diagnosed with hypertension (I10–I13) or prescribed antihypertensive medication before the first health screening examination and had undergone more than 2 health examinations within 4 years between 2002 and 2011. We excluded patients with a prior diagnosis of myocardial infarction (MI; I21–I23) or stroke (I60–I64, I69) (n=62 039) and malignancy (C00–C99; n=55 025) or who died (n=1079) between the first and last health examinations. We also excluded patients with missing values in the health examination database (n=14 897). Finally, 479 359 patients were included in the main analysis. Individuals were followed up until death from any cause or the end of the study period (December 2017) or were censored for the development of MI or stroke (Figure 1).

Sociodemographic Information

As a proxy for income, we used insurance premiums, as determined by government assessments of salary

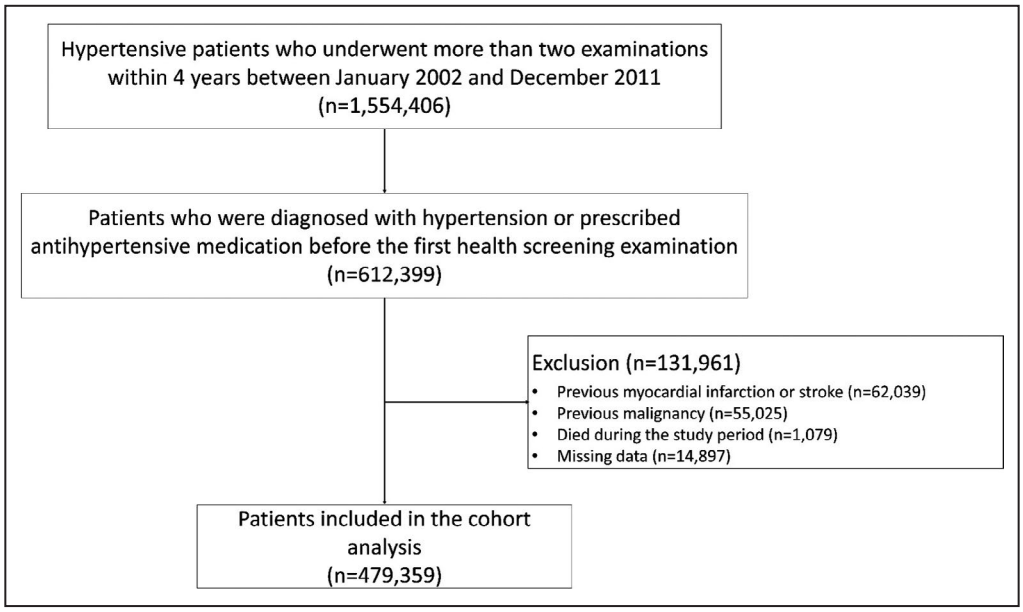

Figure 1. Flowchart of the study population.

and assets. Because health insurance contributions in South Korea are imposed proportionally based on monthly salary, this measure could reflect income level. Household insurance premiums were initially categorized into 20 levels and grouped into quartiles among all households in Korea for the index year (Table S1). People with very low incomes or special care needs are covered by the medical aid program. Medical aid beneficiaries do not pay insurance premiums; their economic statuses are heterogeneous and are not included in income quartiles, and the number of medical aid beneficiaries among the screened people was very small (0.10%), thus we also excluded these participants.

BP Measurement

BP was measured using either sphygmomanometers or oscillometric devices after 3 to 5 minutes of rest at health examination centers or clinics. BP was measured at least twice at 1-minute to 2-minute intervals by qualified medical personnel using an appropriately sized cuff. The protocol for BP measurement is described elsewhere.[13] Baseline BP was defined as the mean values of 2 BP measurements during different health screenings, which we assumed to be representative of the overall BP levels. The study participants were categorized into the following 4 groups according to BP: <130/80, 130 to 139/80 to 89, 140 to 149/90 to 99, ≥150/100 mm Hg.

Follow-Up and Outcome Measurement

Follow-up data obtained for up to 16 years (until 2018) were analyzed. Median follow-up was 9.2 years (interquartile range, 7.0–11.0). The primary end points were all-cause and cardiovascular mortality during the study period. The secondary end points were cardiovascular events: a composite of cardiovascular death, MI, and stroke. All deaths and their causes were retrieved from the mortality records of the National Statistical Office of Korea. Cardiovascular death was defined as death attributed to CVD (I00–I99) by certificate. MI was defined as hospitalization with *ICD-10* codes I21–I23 as a primary or secondary diagnosis. Stroke was defined by discharge diagnosis (*ICD-10* codes I60–I69) among patients who had been hospitalized.[14]

Statistical Analysis

Data are reported as mean±SD or median (interquartile range) for continuous variables and as number (percentage) for categorical variables. The incidence rates were estimated as the total number of outcomes during the follow-up period divided by 100 000 person-years. Cox proportional hazards regression models were used to estimate the effects of income and BP level at baseline on the risk of all-cause and cardiovascular mortality and cardiovascular events with adjustment for covariates, such as age, sex, BP, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. Covariates were carefully selected that were known to affect the outcomes.[15,16] We evaluated between-group differences in risk by income/BP strata by visual inspection of the overlapping of the 95% CI. Subgroup analyses by antihypertensive medication use and

sex were also performed. Statistical analyses were performed using SAS version 9.4 (SAS Institute, Inc., Cary, NC) and R version 3.6.1 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Baseline Characteristics

A total of 479 359 individuals diagnosed with hypertension and with available BP values were followed for 4 415 708 person-years. The baseline characteristics by income level are summarized in Table 1. Their median age was 60 years (interquartile range, 51–68 years), and 57% were women. The age was relatively higher in individuals with the highest income, and women were more prevalent in the lowest income group. BP, alcohol consumption, and body mass index were comparable across income levels. The proportions of current smokers were low in the highest income groups. Individuals with low incomes were less physically active and more likely to have diabetes mellitus and dyslipidemia, whereas individuals with the highest income were more likely to take aspirin, statins, or antihypertensive medications. These patterns were observed regardless of sex, except for a high diabetes mellitus prevalence in women with high incomes (Table S2).

Mortality and Cardiovascular Events According to Income

Table 2 shows the mortality and cardiovascular event rates according to income level. In 4 415 708 person-years, 47 860 deaths were observed. The all-cause and cardiovascular mortality increased gradually with decreasing income. Compared with the highest income group (quartile 1), the lowest group (quartile 4) showed a 26% higher risk of all-cause and 31% higher cardiovascular mortality after adjusting for sex, age, body mass index, smoking, physical activity, comorbidity, and aspirin or statin use. Cardiovascular events showed a similar trend, with the lowest income group showing a 7% higher risk compared with that in the highest income group. The risk of MI and stroke were also high in individuals with low incomes; however, the differences in the risk of these events were not prominent across income levels because the absolute event rates were low. Subgroup analyses by sex also revealed similar results (Table 2).

We further tested whether the associations between income and mortality/cardiovascular events differed by antihypertensive medication use (Table 3). Similar to the main results, mortality and cardiovascular events increased gradually with decreasing income, regardless of antihypertensive medication use; however, the differences in the risk of all-cause and cardiovascular mortality and cardiovascular events across income levels were more prominent in those who were not taking antihypertensive medications.

Mortality and Cardiovascular Events According to Income and BP Levels

The effects of each level of income and BP on mortality and cardiovascular events were determined by comparison to the lowest BP (<130/80 mm Hg) and highest income group. Among individuals with similar BP levels, we observed that low income levels were associated with the risk of high all-cause and cardiovascular mortality and cardiovascular events (Figure 2, Figure S1A). However, in the highest BP (≥150/100 mm Hg) categories, the risk gradient was slightly attenuated in the lowest 2 income groups (quartiles 3 and 4), suggesting that high BP itself is a powerful risk factor. Of note, individuals with the highest income with a BP of 140 to 149/90 to 99 mm Hg had low all-cause mortality (hazard ratio [HR], 1.03; 95% CI, 0.99–1.08) than those with the lowest income with a BP of <130/80 mm Hg (HR, 1.20; 95% CI, 1.14–1.26). In addition, we explored the risk stratified primarily by income and then by BP for each income level (Figure 3, Figure S1B). Among individuals with similar income levels, we observed that high BP was associated with the risk of high all-cause and cardiovascular mortality and cardiovascular events. Even in the highest income group, the all-cause (HR, 1.30; 95% CI, 1.24–1.37) and cardiovascular mortality (HR, 1.38; 95% CI, 1.26–1.52) increase significantly in the individuals with highest BP (≥150/100 mm Hg). Interestingly, J-shaped associations between BP and all-cause mortality as well as cardiovascular mortality were observed in the group with the highest income, with those with a BP of 130 to 139/80 to 89 mm Hg showing a lower risk compared with that in those with a BP of <130/80 mm Hg. Collectively, low income and high BP were associated with a high risk of mortality and cardiovascular events.

DISCUSSION

The main findings of this nationwide study were as follows: (1) patients with hypertension with low incomes were not only likely to have unhealthy behaviors but also had high risks of all-cause and cardiovascular mortality and cardiovascular events, (2) low income and high BP had significant effects on all-cause and cardiovascular mortality risks and cardiovascular events, and (3) the lowest income group had significantly more mortality and cardiovascular events compared with those in other income groups, regardless of BP. The excess risks of mortality and cardiovascular events associated with BP were more prominent in the lowest income group.

Table 1. Baseline Characteristics of the Study Population According to Income Level

	Income				
	Quartile 1, Highest	Quartile 2	Quartile 3	Quartile 4, Lowest	*P* Value
Number of patients	163 347 (34.0)	119 253 (24.9)	92 393 (19.3)	104 366 (21.8)	<0.0001
Age, y	62 (52–70)	59 (50–66)	58 (50–66)	58 (50–66)	<0.0001
Sex					<0.0001
Male	71 570 (43.8)	54 005 (45.3)	41 624 (45.0)	41 176 (39.4)	
Female	91 777 (56.2)	65 248 (54.7)	50 769 (55.0)	63 190 (60.6)	
Blood pressure, mm Hg					<0.0001
Systolic blood pressure	132.4±12.6	132.8±12.9	132.8±13.2	133.1±13.1	
Diastolic blood pressure	81.0±7.9	81.6±8.1	81.8±8.2	81.7±8.1	
Smoking					<0.0001
Never	118 278 (72.4)	82 998 (69.6)	62 740 (67.9)	75 603 (72.4)	
Past	26 193 (16.0)	17 656 (14.8)	13 077 (14.2)	12 809 (12.3)	
Current	18 876 (11.6)	18 599 (15.6)	16 576 (17.9)	15 954 (15.3)	
Physical activity, times/wk					<0.0001
0	84 219 (51.5)	64 876 (54.4)	51 456 (55.7)	59 099 (56.6)	
1–2	23 893 (14.6)	17 548 (14.7)	13 882 (15.0)	14 669 (14.0)	
3–4	20 510 (12.6)	13 967 (11.7)	10 224 (11.1)	11 335 (10.9)	
5–6	14 698 (9.0)	9695 (8.1)	7112 (7.7)	8108 (7.8)	
7	20 027 (12.3)	13 167 (11.1)	9719 (10.5)	11 155 (10.7)	
Alcohol consumption, times/wk					<0.0001
0	111 261 (68.1)	77 812 (65.2)	58 754 (63.6)	69 909 (67.0)	
<1	18 814 (11.5)	14 681 (12.3)	12 032 (13.0)	12 924 (12.4)	
1–2	21 690 (13.3)	17 351 (14.6)	14 280 (15.5)	14 282 (13.7)	
3–4	6274 (3.8)	5030 (4.2)	3926 (4.2)	3855 (3.7)	
≥5	5308 (3.3)	4379 (3.7)	3401 (3.7)	3396 (3.2)	
Body mass index, kg/m^2	24.8±3.2	25.0±3.3	24.9±3.4	24.8±3.4	<0.0001
<18.5	2636 (1.6)	2004 (1.7)	1686 (1.8)	1973 (1.9)	
18.5–22.9	42 312 (25.9)	30 221 (25.3)	24 308 (26.3)	28 254 (27.1)	
23.0–24.9	42 874 (26.3)	30 032 (25.2)	22 698 (24.6)	26 168 (25.1)	
≥25.0	75 525 (46.2)	56 996 (47.8)	43 701 (47.3)	47 971 (45.9)	
Fasting serum glucose, mg/dL	105.0±28.4	105.5±30.5	105.6±31.3	105.8±32.3	0.735
<100.0	87 854 (53.8)	64 184 (53.8)	49 984 (54.1)	56 659 (54.3)	
100.0–125.9	54 380 (33.3)	39 166 (32.8)	30 021 (32.5)	33 568 (32.2)	
≥126.0	21 113 (12.9)	15 903 (13.4)	12 388 (13.4)	14 139 (13.5)	
Total cholesterol, mg/dL	196.3±41.1	197.5±42.9	197.3±40.3	197.7±41.0	<0.0001
<200.0	91 720 (56.2)	65 845 (55.2)	51 318 (55.5)	57 409 (55.0)	
200.0–239.9	51 169 (31.3)	37 458 (31.4)	28 508 (30.9)	32 793 (31.4)	
≥240.0	20 458 (12.5)	15 950 (13.4)	12 567 (13.6)	14 164 (13.6)	
Diabetes mellitus	18 849 (11.5)	13 397 (11.2)	10 007 (10.8)	11 165 (10.7)	<0.0001
Aspirin	43 983 (26.9)	29 557 (24.8)	21 574 (23.4)	25 329 (24.3)	<0.0001
Statin	23 293 (14.3)	15 657 (13.1)	11 175 (12.1)	13 034 (12.5)	<0.0001
Antihypertensive medication	82 321 (50.4)	58 175 (48.8)	44 535 (48.2)	52 561 (50.4)	0.017

Data are expressed as mean±SD, median (interquartile range), or number (percentage).

Previous studies have assessed the effects of SES on CVD and cardiovascular risk factors.[1,6,7,17–21] SES is strongly inversely associated with cardiovascular risk factors and CVD in high-income and middle-income countries. In high-income countries, low income is associated with a high prevalence of cardiovascular risk factors, such as smoking, hypertension, obesity, a sedentary lifestyle, diabetes mellitus, and an unhealthy

Table 2. Incidence of Mortality and Cardiovascular Events According to Income Level in All Patients With Hypertension

	Income			
	Quartile 1, Highest	Quartile 2	Quartile 3	Quartile 4, Lowest
Total				
All-cause mortality				
Events	17 076	11 010	8812	10 962
Person-years	1 518 195	1 097 667	840 612	959 235
Incidence (events/100 000 person-years)	1125	1003	1048	1143
Adjusted HR (95% CI)	Reference	1.12 (1.09–1.15)	1.22 (1.19–1.25)	1.26 (1.23–1.29)
Cardiovascular mortality				
Events	4301	2715	2209	2862
Person-years	1 518 195	1 097 667	840 612	959 235
Incidence (events/100 000 person-years)	283	247	263	298
Adjusted HR (95% CI)	Reference	1.12 (1.06–1.17)	1.24 (1.17–1.30)	1.31 (1.25–1.38)
MI				
Events	3288	2319	1669	2048
Person-years	1 569 652	1 131 642	869 919	997 053
Incidence (events/100 000 person-years)	209	205	192	205
Adjusted HR (95% CI)	Reference	1.06 (1.01–1.12)	1.02 (0.96–1.08)	1.07 (1.01–1.13)
Stroke				
Events	14 885	9764	7396	8729
Person-years	1 497 688	1 086 012	833 855	954 467
Incidence (events/100 000 person-years)	994	899	887	915
Adjusted HR (95% CI)	Reference	1.02 (1.00–1.05)	1.05 (1.02–1.07)	1.04 (1.01–1.06)
Cardiovascular events				
Events	20 041	13 262	10 042	12 056
Person-years	1 470 019	1 067 675	819 874	936 690
Incidence (events/100 000 person-years)	1363	1242	1225	1287
Adjusted HR (95% CI)	Reference	1.04 (1.02–1.06)	1.06 (1.03–1.09)	1.07 (1.05–1.10)
Men				
All-cause mortality				
Events	9174	6268	5061	6085
Person-years	687 336	506 781	378 642	374 375
Incidence (events/100 000 person-years)	1335	1237	1337	1625
Adjusted HR (95% CI)	Reference	1.13 (1.09–1.17)	1.25 (1.21–1.29)	1.28 (1.24–1.32)
Cardiovascular mortality				
Events	2066	1394	1129	1411
Person-years	687 336	506 781	378 642	374 375
Incidence (events/100 000 person-years)	301	275	298	377
Adjusted HR (95% CI)	Reference	1.13 (1.05–1.21)	1.25 (1.16–1.35)	1.32 (1.23–1.42)
MI				
Events	1847	1351	973	1121
Person-years	715 961	527 122	396 386	396 348
Incidence (events/100 000 person-years)	258	256	245	283
Adjusted HR (95% CI)	Reference	1.06 (0.99–1.14)	1.02 (0.94–1.10)	1.07 (1.00–1.16)
Stroke				
Events	6711	4583	3409	3958
Person-years	684 862	506 801	380 780	377 989
Incidence (events/100 000 person-years)	980	904	895	1047

(*Continued*)

Table 2. Continued

	Income			
	Quartile 1, Highest	Quartile 2	Quartile 3	Quartile 4, Lowest
Adjusted HR (95% CI)	Reference	1.04 (1.00–1.08)	1.03 (0.99–1.08)	1.05 (1.01–1.10)
Cardiovascular events				
Events	9483	6545	4910	5758
Person-years	669 098	496 195	372 566	368 083
Incidence (events/100 000 person-years)	1417	1319	1318	1564
Adjusted HR (95% CI)	Reference	1.04 (1.01–1.08)	1.05 (1.01–1.09)	1.09 (1.05–1.12)
Women				
All-cause mortality				
Events	7902	4742	3751	4877
Person-years	830 859	590 886	461 969	584 860
Incidence (events/100 000 person-years)	951	803	812	834
Adjusted HR (95% CI)	Reference	1.10 (1.06–1.14)	1.17 (1.13–1.22)	1.21 (1.17–1.26)
Cardiovascular mortality				
Events	2235	1321	1080	1451
Person-years	830 859	590 886	461 969	584 860
Incidence (events/100 000 person-years)	269	224	234	248
Adjusted HR (95% CI)	Reference	1.10 (1.02–1.17)	1.20 (1.12–1.29)	1.28 (1.20–1.37)
MI				
Events	1441	968	696	927
Person-years	853 692	604 520	473 533	600 705
Incidence (events/100 000 person-years)	169	160	147	154
Adjusted HR (95% CI)	Reference	1.07 (0.99–1.16)	1.03 (0.94–1.13)	1.11 (1.02–1.21)
Stroke				
Events	8174	5181	3987	4771
Person-years	812 826	579 211	453 075	576 478
Incidence (events/100 000 person-years)	1006	894	880	828
Adjusted HR (95% CI)	Reference	1.01 (0.98–1.05)	1.05 (1.01–1.09)	1.02 (0.98–1.06)
Cardiovascular events				
Events	10 558	6717	5132	6298
Person-years	800 921	571 480	447 308	568 607
Incidence (events/100 000 person-years)	1318	1175	1147	1108
Adjusted HR (95% CI)	Reference	1.03 (1.00–1.07)	1.07 (1.03–1.10)	1.06 (1.03–1.10)

HR was adjusted for age, sex, blood pressure level, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. HR indicates hazard ratio; and MI, myocardial infarction.

diet as well as high CVD incidence and mortality.[19] A recent meta-analysis revealed increased pooled risk ratios for low-income versus high-income groups for coronary artery disease, cardiovascular events, stroke, and cardiovascular-related deaths.[11] In another meta-analysis, Backholer et al also reported increased pooled relative risks in low-income versus high-income groups for coronary heart disease, stroke, and all CVDs, with no evidence of the differential effect of income by sex.[22] However, few studies have assessed whether income as an indicator of SES affects mortality and cardiovascular outcomes in patients with hypertension. Using a nationwide population-based database, our study demonstrated income-related excess risks in terms of all-cause mortality, cardiovascular mortality, MI, and stroke among patients with hypertension. These findings were observed regardless of antihypertensive medication use or sex. Our study also revealed even greater combined effects of BP and income on mortality and cardiovascular events. In our study, both uncontrolled BP and low income were associated with a significantly increased risk of all-cause and cardiovascular mortality and cardiovascular events, with synergistic increases in the risks of mortality and cardiovascular events if both conditions were present.

Several interrelated pathways may explain how income level affects the relationship between hypertension

Table 3. Mortality and Cardiovascular Events for Individuals According to Income and Antihypertensive Medication Use

	With Antihypertensive Medications				Without Antihypertensive Medications			
	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest
Total								
All-cause mortality								
Events	9071	5610	4304	5575	8005	5400	4508	5387
Person-years	737 894	517 603	394 595	469 564	780 300	580 063	446 017	489 671
Incidence (events/100 000 person-years)	1229	1084	1091	1187	1026	931	1011	1100
Adjusted HR (95% CI)	Reference	1.11 (1.07–1.15)	1.16 (1.12–1.21)	1.23 (1.19–1.27)	Reference	1.13 (1.09–1.17)	1.28 (1.24–1.33)	1.29 (1.24–1.33)
Cardiovascular mortality								
Events	2318	1438	1111	1476	1983	1277	1098	1386
Person-years	737 894	517 603	394 595	469 564	780 300	580 063	446 017	489 671
Incidence (events/100 000 person-years)	314	278	282	314	254	220	246	283
Adjusted HR (95% CI)	Reference	1.13 (1.06–1.21)	1.19 (1.11–1.28)	1.29 (1.21–1.38)	Reference	1.10 (1.03–1.18)	1.28 (1.19–1.38)	1.32 (1.24–1.42)
MI								
Events	1700	1144	812	1050	1588	1175	857	998
Person-years	764 454	534 408	408 125	487 831	805 198	597 234	461 793	509 221
Incidence (events/100 000 person-years)	222	214	199	215	197	197	186	196
Adjusted HR (95% CI)	Reference	1.03 (0.95–1.11)	0.97 (0.89–1.06)	1.04 (0.97–1.13)	Reference	1.10 (1.02–1.19)	1.07 (0.98–1.16)	1.10 (1.01–1.19)
Stroke								
Events	7637	4801	3629	4401	7248	4963	3767	4328
Person-years	728 920	512 856	390 932	467 584	768 768	573 156	442 922	486 883
Incidence (events/100 000 person-years)	1048	936	928	941	943	866	850	889
Adjusted HR (95% CI)	Reference	1.00 (0.96–1.04)	1.02 (0.98–1.07)	1.02 (0.98–1.06)	Reference	1.05 (1.01–1.09)	1.07 (1.02–1.11)	1.05 (1.01–1.09)
Cardiovascular events								
Events	10 402	6587	4964	6130	9639	6675	5078	5926
Person-years	714 809	504 078	384 173	458 767	755 209	563 597	435 701	477 923
Incidence (events/100 000 person-years)	1455	1307	1292	1336	1276	1184	1165	1240
Adjusted HR (95% CI)	Reference	1.01 (0.98–1.04)	1.03 (1.00–1.07)	1.05 (1.01–1.08)	Reference	1.07 (1.03–1.10)	1.09 (1.05–1.12)	1.09 (1.06–1.13)
Men								
All-cause mortality								
Events	4728	3070	2389	3081	4446	3198	2672	3004
Person-years	323 302	231 076	176 407	188 700	364 034	275 705	202 234	185 674
Incidence (events/100 000 person-years)	1462	1329	1354	1633	1221	1160	1321	1618
Adjusted HR (95% CI)	Reference	1.10 (1.05–1.15)	1.17 (1.11–1.23)	1.24 (1.18–1.29)	Reference	1.16 (1.11–1.22)	1.33 (1.27–1.39)	1.32 (1.26–1.39)

(*Continued*)

Table 3. Continued

	With Antihypertensive Medications				Without Antihypertensive Medications			
	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest
Cardiovascular mortality								
Events	1075	692	547	713	991	702	582	698
Person-years	323 302	231 076	176 407	188 700	364 034	275 705	202 234	185 674
Incidence (events/100 000 person-years)	333	299	310	378	272	255	288	376
Adjusted HR (95% CI)	Reference	1.09 (0.99–1.20)	1.18 (1.07–1.31)	1.26 (1.14–1.38)	Reference	1.17 (1.06–1.29)	1.31 (1.18–1.46)	1.37 (1.25–1.52)
MI								
Events	906	682	469	590	941	669	504	531
Person-years	337 547	240 418	184 241	199 014	378 413	286 704	212 145	197 334
Incidence (events/100 000 person-years)	268	284	255	296	249	233	238	269
Adjusted HR (95% CI)	Reference	1.09 (0.99–1.21)	0.98 (0.88–1.10)	1.08 (0.98–1.20)	Reference	1.03 (0.93–1.14)	1.05 (0.94–1.17)	1.06 (0.95–1.18)
Stroke								
Events	3346	2171	1645	2029	3365	2412	1764	1929
Person-years	322 408	231 559	176 907	190 155	362 453	275 242	203 872	187 834
Incidence (events/100 000 person-years)	1038	938	930	1067	928	876	865	1027
Adjusted HR (95% CI)	Reference	0.99 (0.94–1.04)	1.00 (0.94–1.06)	1.04 (0.98–1.10)	Reference	1.09 (1.03–1.14)	1.06 (1.00–1.13)	1.07 (1.01–1.13)
Cardiovascular events								
Events	4760	3166	2384	2975	4723	3379	2526	2783
Person-years	314 792	226 436	173 000	185 150	354 305	269 758	199 566	182 933
Incidence (events/100 000 person-years)	1512	1398	1378	1607	1333	1253	1266	1521
Adjusted HR (95% CI)	Reference	1.01 (0.96–1.05)	1.02 (0.97–1.07)	1.07 (1.02–1.12)	Reference	1.08 (1.03–1.13)	1.09 (1.03–1.14)	1.10 (1.05–1.15)
Women								
All-cause mortality								
Events	4343	2540	1915	2494	3559	2202	1836	2383
Person-years	414 593	286 528	218 187	280 864	416 266	304 358	243 782	303 996
Incidence (events/100 000 person-years)	1048	886	878	888	855	723	753	784
Adjusted HR (95% CI)	Reference	1.11 (1.06–1.17)	1.14 (1.08–1.20)	1.21 (1.15–1.27)	Reference	1.08 (1.03–1.14)	1.21 (1.15–1.28)	1.22 (1.16–1.29)
Cardiovascular mortality								
Events	1243	746	564	763	992	575	516	688
Person-years	414 593	286 528	218 187	280 864	416 266	304 358	243 782	303 996
Incidence (events/100 000 person-years)	300	260	258	272	238	189	212	226
Adjusted HR (95% CI)	Reference	1.16 (1.06–1.27)	1.18 (1.06–1.30)	1.30 (1.19–1.42)	Reference	1.03 (0.93–1.14)	1.24 (1.11–1.38)	1.25 (1.14–1.38)
MI								

(*Continued*)

Table 3. Continued

	With Antihypertensive Medications				Without Antihypertensive Medications			
	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest	Income Quartile 1, Highest	Income Quartile 2	Income Quartile 3	Income Quartile 4, Lowest
Events	794	462	343	460	647	506	353	467
Person-years	426 907	293 990	223 885	288 818	426 784	310 530	249 648	311 887
Incidence (events/100 000 person-years)	186	157	153	159	152	163	141	150
Adjusted HR (95% CI)	Reference	0.95 (0.85–1.07)	0.96 (0.85–1.10)	1.04 (0.93–1.17)	Reference	1.21 (1.07–1.36)	1.10 (0.97–1.26)	1.18 (1.05–1.34)
Stroke								
Events	4291	2630	1984	2372	3883	2551	2003	2399
Person-years	406 511	281 297	214 025	277 429	406 314	297 914	239 050	299 049
Incidence (events/100 000 person-years)	1056	935	927	855	956	856	838	802
Adjusted HR (95% CI)	Reference	1.01 (0.96–1.06)	1.04 (0.98–1.10)	1.00 (0.95–1.05)	Reference	1.02 (0.97–1.07)	1.06 (1.01–1.12)	1.03 (0.98–1.09)
Cardiovascular events								
Events	5642	3421	2580	3155	4916	3296	2552	3143
Person-years	400 017	277 642	211 173	273 617	400 904	293 838	236 135	294 990
Incidence (events/100 000 person-years)	1410	1232	1222	1153	1226	1122	1081	1065
Adjusted HR (95% CI)	Reference	1.02 (0.97–1.06)	1.05 (1.00–1.10)	1.03 (0.99–1.08)	Reference	1.05 (1.01–1.10)	1.09 (1.04–1.14)	1.09 (1.04–1.14)

HR was adjusted for age, sex, levels of blood pressure, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. HR indicates hazard ratio; and MI, myocardial infarction.

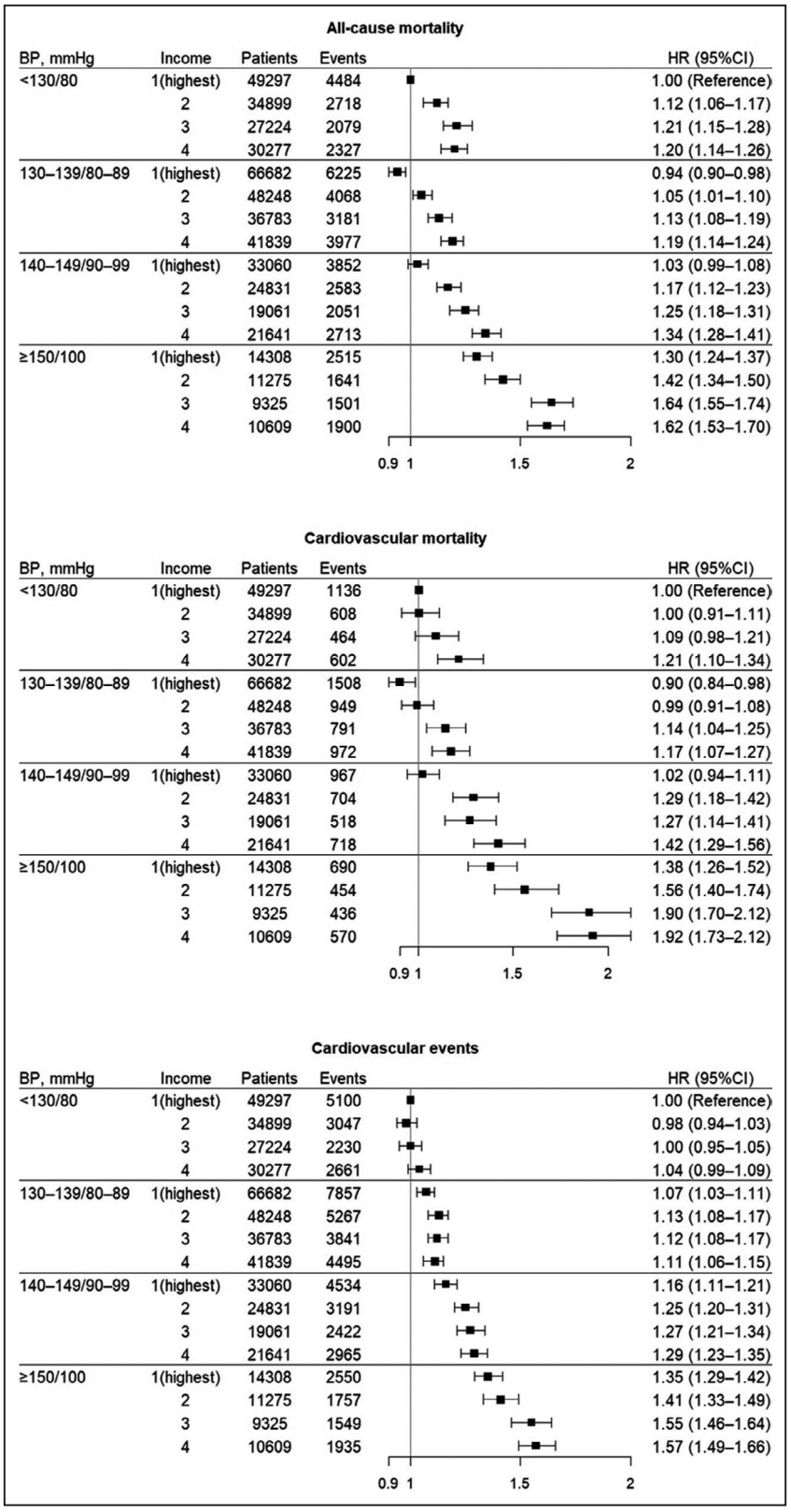

Figure 2. Mortality and cardiovascular events rates for 16 groups, stratified primarily by BP and then by income for each BP level.
A Cox proportional hazard regression model adjusted for age, sex, BP, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. The *x* axis refers to HR (95% CI), and HR itself (not log [HR]) was plotted. BP indicates blood pressure; and HR, hazard ratio.

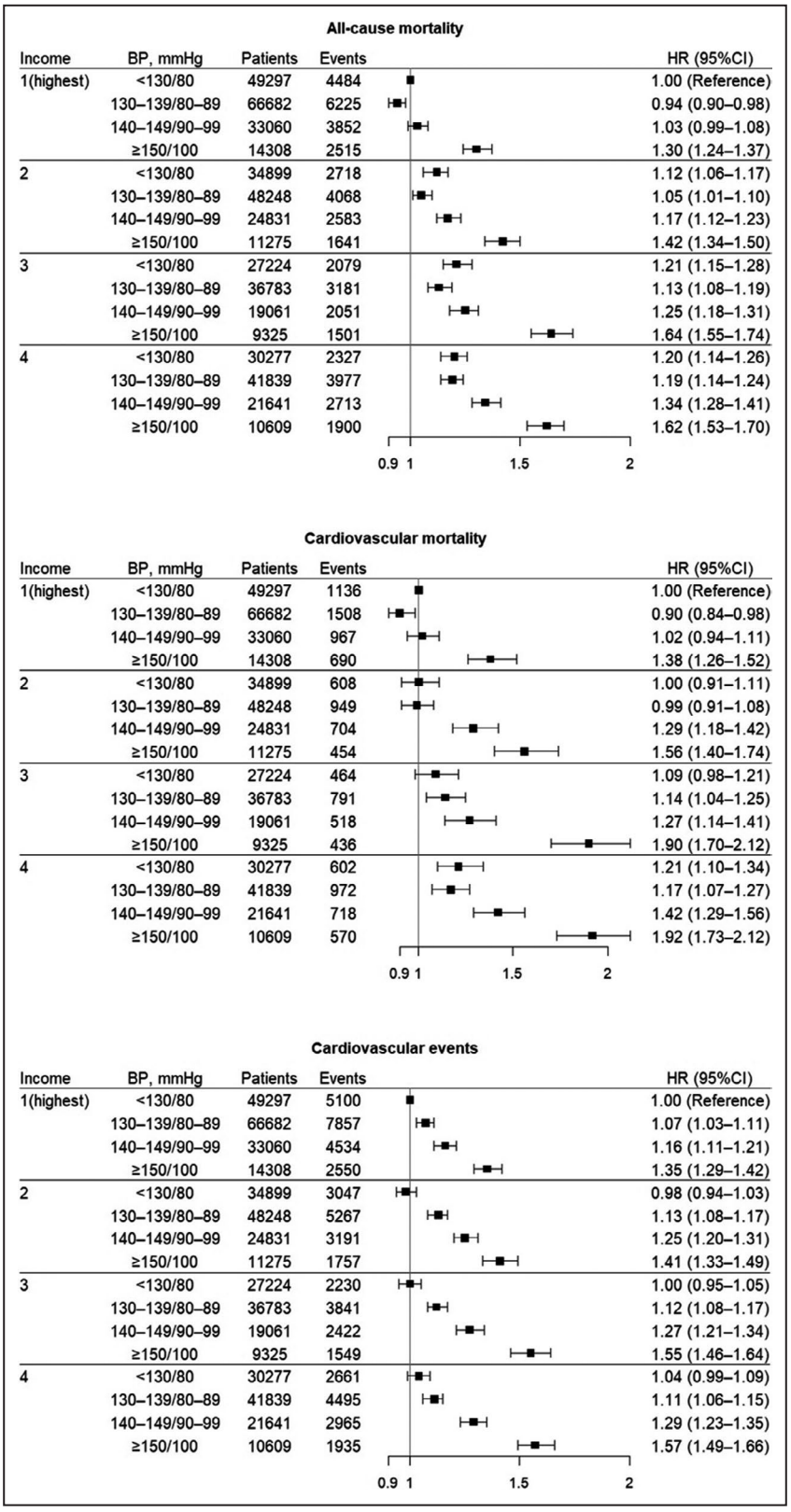

Figure 3. Mortality and cardiovascular events rates for 16 groups, stratified primarily by income and then by BP for each income level.
A Cox proportional hazard regression model adjusted for age, sex, BP, body mass index, smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. The *x* axis refers to HR (95% CI), and HR itself (not log [HR]) was plotted. BP indicates blood pressure; and HR, hazard ratio.

and mortality or cardiovascular events. First, patients with high SES tend to have a high awareness of hypertension prevention and control and better accessibility and adherence to medical treatment. We also observed that a high income was associated with a high rate of administration of antihypertensive medications, aspirin, or statins; their preventive effect against cardiovascular events may have contributed to the inverse association between SES and mortality or cardiovascular events. However, income-related adverse outcomes remained robust in the group without antihypertensive medication use, suggesting an independent role of income level as a potent risk factor. Second, the mechanisms driving socioeconomic inequalities in CVD are affected by multiple factors, such as the approachability, acceptability, availability, and affordability of medical services.[23] A recent systematic review showed an association between low SES and reduced access to coronary procedures and secondary prevention, which may explain the high risk of CVD death among disadvantaged groups.[24] We observed that the differences in cardiovascular mortality among income levels were obvious compared with those in MI or stroke. Further research is needed to evaluate disparities in access to medical care, including approachability, availability, accommodation, affordability, and acceptability according to income levels.[23] Third, patients with low SES are more likely to have unhealthy lifestyle behaviors and comorbid conditions, which lead to increased mortality.[25] The current study showed that individuals with the highest income were more physically active and less likely to have diabetes mellitus and dyslipidemia. Moreover, the proportion of current smokers was low in the highest income groups. Collectively, the mechanism by which low SES contributes to adverse outcomes is complicated by a variety of health behavioral factors, comorbid conditions, and out-of-disease factors intertwined with each other, which warrants further study.

This study has several strengths. Clinically, it is the largest study to demonstrate the effect of income on mortality and cardiovascular outcomes in patients with hypertension. Our study focused on income as a proxy for SES. Despite the relevance of income as a measure of socioeconomic factors, the income-related issue has received less attention than other SES measures or conventional cardiovascular risk factors in most epidemiologic studies, partly because it is sensitive information. To our knowledge, this is the first study to examine the combined effects of income and BP on mortality and cardiovascular events in patients with hypertension. Moreover, we analyzed a large sample of Korean adults, which allowed for comparisons of 16 groups based on income and BP and analyses of all-cause and cardiovascular mortality risks and cardiovascular events. From a research perspective, our study provided evidence to support the associations among income, mortality, and cardiovascular events in patients with hypertension.

This study has several limitations. First, its retrospective design limited the investigation of causal relationships. Second, income level, which was used as a proxy for SES, was assessed based on total household income unadjusted for the number of household members because of the lack of information regarding the number of household members, which might not assess accurate income level. Furthermore, SES is a complex factor comprising several dimensions (income, education, employment status, occupational position, and neighborhood socioeconomic characteristics). Thus, our use of a single indicator of SES might have underestimated its full effect on mortality and cardiovascular events. Third, this study included patients with hypertension who had undergone at least 2 health check-ups to assess the association between mean BP outcomes in these patients; however, these may not be representative of the entire hypertensive population. This cohort tended to include more individuals with health concerns and high SES.[26] Fourth, because this study used *ICD-10* diagnosis codes rather than adjudicated events, we cannot rule out diagnostic inaccuracies for nonfatal cardiovascular events. Fifth, we only included cardiovascular death and a new diagnosis of MI and stroke as cardiovascular events because these are major events that can be used to evaluate the long-term prognosis of patients with hypertension and can be clearly identified by the *ICD* code from the NHIS data. However, misclassifying or underestimating a diagnosis based on the *ICD* code was still a possibility. Finally, this study was based on Korean adults under universal health insurance and should be interpreted with caution when applied to different populations or different healthcare systems.

Perspectives

Income is significantly associated with the risk of all-cause mortality, cardiovascular mortality, and cardiovascular events among patients with hypertension. The risks of mortality and cardiovascular events are high in those with low incomes and high BP. These findings suggest that income is an important aspect of social determinants of health that has an impact on cardiovascular outcomes in the care of hypertension.

ARTICLE INFORMATION

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Disclosures

None.

Supplementary Material

Tables S1–S2
Figure S1

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SUPPLEMENTAL MATERIAL

Table S1. South Korea's 2018 National Health Insurance Statistics for household insurance premiums by the National Health Insurance Service.

Premium quintile	Number of Households	Average premium: won(dollar)/months	Number of population
Sum	24,748,873	101,606 (93.05)	49,562,166
1st	1,237,443	16,557 (15.16)	1,814,442
2nd	1,237,443	27,037 (24.76)	1,955,041
3rd	1,237,444	33,176 (30.38)	1,976,086
4th	1,237,444	37,291 (34.15)	1,924,347
5th	1,237,444	38,964 (35.68)	1,935,777
6th	1,237,443	41,565 (38.06)	1,928,656
7th	1,237,444	45,693 (41.84)	1,978,637
8th	1,237,444	50,459 (46.21)	2,032,583
9th	1,237,443	56,771 (51.99)	2,100,568
10th	1,237,445	64,946 (59.47)	2,200,270
11th	1,237,443	73,407 (67.22)	2,260,176
12th	1,237,443	83,481 (76.45)	2,388,702
13th	1,237,444	94,238 (86.30)	2,532,407
14th	1,237,444	106,477 (97.51)	2,651,569
15th	1,237,444	121,119 (110.91)	2,834,906
16th	1,237,443	138,802 (127.11)	3,018,399
17th	1,237,444	161,051 (147.48)	3,202,745
18th	1,237,444	190,327 (174.29)	3,480,502

19th	1,237,443	232,961 (213.33)	3,641,281
20th	1,237,444	417,793 (382.59)	3,705,072

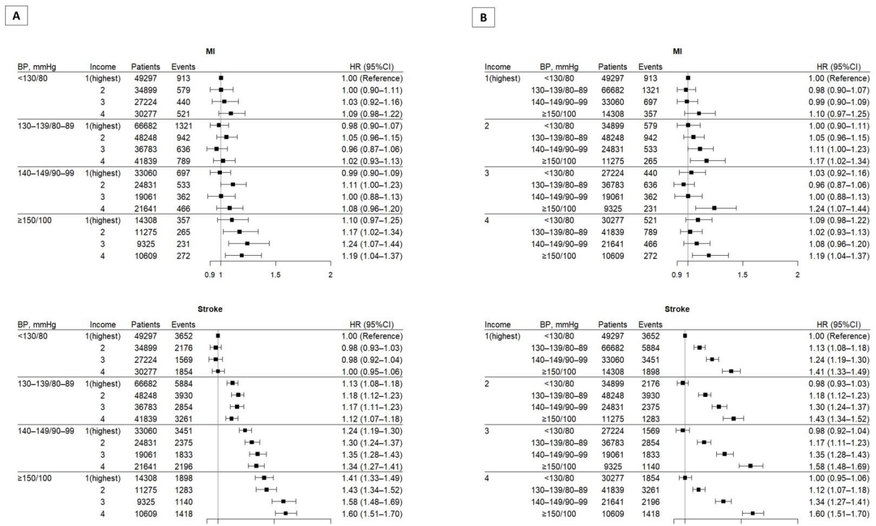
Table S2. Baseline characteristics of the study population according to income level, stratified by sex.

	Men					Women				
Income	Q1, highest	Q2	Q3	Q4	*P* value	Q1, highest	Q2	Q3	Q4	*P* value
Number of patients (%)	71570 (34.3)	54005 (25.9)	41624 (20.0)	41176 (21.8)	<0.0001	91777 (44.0)	65248 (31.3)	50769 (24.4)	63190 (30.3)	<0.0001
Age (years)	58 (50-68)	56 (46-66)	56 (46-64)	59 (52-66)	<0.0001	64 (55-70)	60 (54-68)	58 (52-66)	58 (50-66)	<0.0001
Blood pressure (mmHg)					<0.0001					<0.0001
Systolic blood pressure	133.1 ± 12.0	133.8 ± 12.3	134.1 ± 12.6	135.0 ± 12.7		131.9 ± 85.0	131.9 ± 13.2	131.7 ± 13.5	131.8 ± 13.2	
Diastolic blood pressure	82.3 ± 7.8	82.9 ± 8.0	83.1 ± 8.2	83.1 ± 8.1		80.0 ± 7.9	80.5 ± 8.0	80.7 ± 8.1	80.8 ± 8.0	
Smoking (%)					<0.0001					<0.0001
Never	28693 (40.1)	20034 (37.1)	14448 (34.7)	15259 (37.1)		89585 (97.6)	62964 (96.5)	48292 (95.1)	60344 (95.5)	
Past	25418 (35.5)	16927 (31.3)	12336 (29.6)	12056 (29.3)		775 (0.8)	729 (1.1)	741 (1.5)	753 (1.2)	
Current	17459 (24.4)	17044 (31.6)	14840 (35.7)	13861 (33.7)		1417 (1.5)	1555 (2.4)	1736 (3.4)	2093 (3.3)	
Physical activity, times/week (%)					<0.0001					<0.0001
0	29915 (41.8)	24810 (45.9)	19765 (47.5)	20027 (48.6)		54304 (59.2)	40066 (61.4)	31691 (62.4)	39072 (61.8)	
1-2	12637 (17.7)	9725 (18.0)	7471 (17.9)	6599 (16.0)		11256 (12.3)	7823 (12.0)	6411 (12.6)	8070 (12.8)	
3-4	10496 (14.7)	7395 (13.7)	5372 (12.9)	5212 (12.7)		10014 (10.9)	6572 (10.1)	4852 (9.6)	6123 (9.7)	
5-6	7669 (10.7)	5013 (9.3)	3772 (9.1)	3771 (9.2)		7029 (7.7)	4682 (7.2)	3340 (6.6)	4337 (6.9)	
7	10853 (15.2)	7062 (13.1)	5244 (12.6)	5567 (13.5)		9174 (10.0)	6105 (9.4)	4475 (8.8)	5588 (8.8)	
Alcohol consumption, times/week (%)					0.128					<0.0001
0	28836 (40.3)	20942 (38.8)	16099 (38.7)	17103 (41.5)		82425 (89.8)	56870 (87.2)	42655 (84.0)	52806 (83.6)	
<1	13172 (18.4)	9870 (18.3)	7494 (18.0)	6842 (16.6)		5642 (6.1)	4811 (7.4)	4538 (8.9)	6082 (9.6)	
1-2	18969 (26.5)	14679 (27.2)	11601 (27.9)	10934 (26.6)		2721 (3.0)	2672 (4.1)	2679 (5.3)	3348 (5.3)	
3-4	5824 (8.1)	4602 (8.5)	3477 (8.4)	3379 (8.2)		450 (0.5)	428 (0.7)	449 (0.9)	476 (0.8)	
≥5	4769 (6.7)	3912 (7.2)	2953 (7.1)	2918 (7.1)		539 (0.6)	467 (0.7)	448 (0.9)	478 (0.8)	
Body mass index (kg/m^2)	24.9 ± 3.0	25.0 ± 3.2	25.0 ± 3.3	24.8 ± 3.2	<0.0001	24.8 ± 3.3	25.0 ± 3.4	25.0 ± 3.5	24.9 ± 3.5	0.001
<18.5	1010 (1.4)	833 (1.5)	674 (1.6)	746 (1.8)		1626 (1.8)	1171 (1.8)	1012 (2.0)	1227 (1.9)	
18.5–22.9	16584 (23.2)	12832 (23.8)	10558 (25.4)	10851 (26.4)		25728 (28.0)	17389 (26.7)	13750 (27.1)	17403 (27.5)	
23.0–24.9	19703 (27.5)	14246 (26.4)	10728 (25.8)	10792 (26.2)		23171 (25.2)	15786 (24.2)	11970 (23.6)	15376 (24.3)	
≥25.0	34273 (47.9)	26094 (48.3)	19664 (47.2)	18787 (45.6)		41252 (44.9)	30902 (47.4)	24037 (47.3)	29184 (46.2)	
Fasting serum glucose (mg/dL)	107.6 ± 30.0	108.0 ± 33.2	108.4 ± 34.6	110.1 ± 36.5	<0.0001	102.9 ± 26.9	103.5 ± 27.9	103.3 ± 28.0	103.1 ± 28.9	0.228

<100.0	34458 (48.1)	26644 (49.3)	20477 (49.2)	19592 (47.6)		53396 (58.2)	37540 (57.5)	29507 (58.1)	37067 (58.7)	
100.0–125.9	26044 (36.4)	19004 (35.2)	14531 (34.9)	14420 (35.0)		28336 (30.9)	20162 (30.9)	15490 (30.5)	19148 (30.3)	
≥126.0	11068 (15.5)	8357 (15.5)	6616 (15.9)	7164 (17.4)		10045 (10.9)	7546 (11.6)	5772 (11.4)	6975 (11.0)	
Total cholesterol (mg/dL)	189.8 ± 39.0	191.7 ± 42.1	191.2 ± 38.3	190.6 ± 39.9	0.001	201.3 ± 42.0	202.3 ± 43.1	202.2 ± 41.2	202.3 ± 41.1	<0.0001
<200.0	44924 (62.8)	33015 (61.1)	25616 (61.5)	25652 (62.3)		46796 (51.0)	32830 (50.3)	25702 (50.6)	31757 (50.3)	
200.0–239.9	20239 (28.3)	15594 (28.9)	11747 (28.2)	11538 (28.0)		30930 (33.7)	21864 (33.5)	16761 (33.0)	21255 (33.6)	
≥240.0	6407 (9.0)	5396 (10.0)	4261 (10.2)	3986 (9.7)		14051 (15.3)	10554 (16.2)	8306 (16.4)	10178 (16.1)	
Diabetes mellitus (%)	8404 (11.7)	5992 (11.1)	4599 (11.0)	5127 (12.5)	0.020	10445 (11.4)	7405 (11.3)	5408 (10.7)	6038 (9.6)	<0.0001
Aspirin (%)	20624 (28.8)	13804 (25.6)	9931 (23.9)	11029 (26.8)	<0.0001	23359 (25.5)	15753 (24.1)	11643 (22.9)	14300 (22.6)	<0.0001
Statin (%)	9205 (12.9)	6302 (11.7)	4446 (10.7)	4774 (11.6)	<0.0001	14088 (15.4)	9355 (14.3)	6729 (13.3)	8260 (13.1)	<0.0001
Antihypertensive medication (%)	35143 (49.1)	25543 (47.3)	19792 (47.5)	21253 (51.6)	<0.0001	47178 (51.4)	32632	24743 (48.7)	31308 (49.5)	<0.0001

Data are expressed as mean ± standard deviation, median (interquartile range), or number (percentage).

Figure S1. Risk of myocardial infarction and stroke for 16 groups, classified according to income and blood pressure levels.



A Cox proportional hazard regression model adjusted for age, sex, BP, body mass index (BMI), smoking status, alcohol consumption, physical activity, fasting glucose, total cholesterol, and aspirin or statin use. The X-axis refers to HR (95% CI) and HR itself (not log[HR]) was plotted. HR indicates hazard ratio.