BMJ Open

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Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-014070
Article Type:	Research
Date Submitted by the Author:	29-Aug-2016
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, Health policy, Public health
Keywords:	Health inequality, cardiovascular disease, trend

Gender differences in trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population: results from the Korea National Health and Nutrition Examination Survey, 2001-2014

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Word count:2984

ABSTRACT

Objectives: To examine the trends in socioeconomic inequalities in major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia)

Design: Cross-sectional study

Setting: A nationally representative population survey data

Participants: A total of 42,725 Koreans, aged 25-64 years, using data from the Korean National Health and Nutrition Examination Survey II (2001) to VI (2013-2014).

Main outcome measures: Trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia)

Results Gender differences were noted in the time trends in socioeconomic inequalities in smoking, obesity, diabetes and hypertension. Among men, low SES was associated with higher prevalence of smoking, but not with obesity, diabetes or hypertension. Indeed, magnitudes of socioeconomic inequalities in smoking, obesity and diabetes remained unchanged, and the magnitude of the inequality in hypertension decreased over time. However, among women low SES was associated with high prevalences of smoking, obesity, diabetes and hypertension. Time trends towards increasing socioeconomic inequalities, measured by income, in smoking, obesity and diabetes were found in women. Unlike the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequalities.

Conclusions SES had a stronger impact on major CVD risk factors among Korean women than men. Moreover, socioeconomic inequalities in smoking, obesity and diabetes worsened

among Korean women over time. Public policies to prevent smoking, obesity and diabetes in women in lower SES groups are needed to address inequalities.

Keywords: Trend, health inequality, cardiovascular disease

Strengths and limitations of the study

- This study shows that SES has stronger impact on major CVD risk factors (smoking, obesity, hypertension, diabetes mellitus) among Korean women than men.
- Among Korean women, socioeconomic inequalities in smoking, obesity and diabetes has been worsened over past fourteen years.
- It is difficult to determine causal relationships between SES and CVD risk factors because of the cross-sectional design of the study.

INTRODUCTION

Socioeconomic status (SES) has shown inverse associations with cardiovascular disease (CVD) in most industrialised Western countries, such that disadvantaged groups experience higher risks for CVD.[1-2] A considerable portion of the association between SES and CVD has been attributed to the combined effects of inequalities in health-related behaviours, environmental conditions, social structures and contact with and delivery of healthcare services.[3] As CVD mortality and morbidity contribute sizeable proportions to overall health inequality, attempts to reduce these causes of death are public health concerns.[4] Previous studies have shown that a greater decline in the prevalence of CVD risk factors among higher SES groups widened the gap between different SES groups over time in the US over time.[5-6] However, studies in England and Australia failed to provide strong evidence of that socioeconomic inequalities in CVD risk factors had increased in recent decades.[7-8]

Korea, a recently developed country, has experienced rapid socioeconomic growth during the last 50 years. There has been a 10-fold increase in the per capita gross national income over the past 30 years (to $27,000 US in 2015), but, at the same time, there has also been a widening gap in socioeconomic circumstances.[9-10] Thus, it remains unclear whether the increased overall wealth has resulted in improved health status across all segments of the population.

To our knowledge, no previous study has examined time trends in socioeconomic inequalities with regard to major CVD risk factors in Koreans. The purpose of this study was to examine recent national trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia) by gender using a nationwide survey data.

METHODS

Study participants

This study was based on data from five consecutive Korean National Health and Nutrition Examination Surveys (KNHANES) conducted from 2001 to 2014. A detailed description of the survey design and data collection in the KNHANES has been published before.[11] The KNHANES was initiated in 1998 and has been conducted as a series of surveys. We excluded the data from KNHANES I (1998) due to a lack of reliability.[12-13] Representative households of non-institutionalised Koreans residing in Korea were selected using a stratified and multi-stage clustered probability sampling method. The response rates in the target population ranged from 70.2% to 86.5%. In this study, the study population was limited to adults aged 25-64 years old to examine trends in socioeconomic inequalities. Considering the applicability of socioeconomic measures (such as education level and household income), we excluded survey participants aged younger than 25 who may not have completed their education or have no job and those older than 64 because they were mostly economically inactive. The total number of participants in the analysis was 42,725; 6,673 for the KNHANES II (2001), 6,134 for the KNHANES III (2005), 12,366 for the KNHANES IV (2007-2009), 12,911 for the KNHANES V (2010-2012), and 7,812 for the KNHANES VI (2013-2014).

Health interview and health examination survey

The KNHANES consists of three components: a health interview, a health examination, and a

nutrition survey. The health interview survey collects detailed information on SES (e.g. education level, household income), smoking and drinking behaviours, and healthcare utilisation. Prior diagnosis of diabetes and hypertension by a physician and current use of anti-hypertensive and anti-hyperglycaemic agents are included in the questionnaire. Height to the nearest 0.1 cm was measured using portable stadiometers. Weight to the nearest 0.1 kg was measured using a portable electronic scale. According to the standard protocol, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained nurses using a mercury sphygmomanometer (Baumanometer Desk model; Baum, NY, USA) on the right arm of the subject while sitting after at least 5 min of rest.

Blood sample collection and biochemical analysis

Venous blood samples were obtained from each participant in the morning after fasting for at least 8 h. All samples were processed according to the protocols of KNHANES. After blood collection, an 8-mL serum separating tube for analysing blood lipid level was kept at room temperature for 30 min, and the blood was subsequently centrifuged (3000 rpm, 15 min). A 2-ml sodium fluoride tube for analysing glucose levels was mixed in a roller mixer for 10 min. All blood samples were refrigerated at 2-8°C and then transported to the central laboratory. Within 24 h of blood collection, plasma concentrations of glucose and lipid were assayed using an Advia 1650 (Siemens, NY, USA) in 2005 and 2007 and using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) since 2008. Since 2005, all laboratory analyses were performed according to the protocol and monitored to ensure the values met acceptable standards of precision and reproducibility in a central laboratory. Because quality control for the biochemical analysis of blood was started by the KCDC in 2005, we analysed the data on

serum glucose and total cholesterol that were collected since 2005 in this study.

Socioeconomic status (SES) indicators

Education level and income were used as SES indicators. Education level was grouped into four categories by years completed: college or higher (≥13 years), high school (10-12 years), middle school (7-9 years), elementary school or less (≤6 years). The measure of income was equivalised gross household income per month, defined as household income/number of family members$^{0.5}$ to adjust for an effect of the number of individuals in the household; we used an equivalence scale of 0.5 for household size. We divided study subjects into four groups according to quartiles of equivalised monthly household income by gender and age (Q1–Q4; Q1, highest quartile; Q4, lowest quartile).

Definition of CVD risk factors

Cigarette smoking was defined as a "yes" answer to both of the following questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as a BMI of ≥25 kg/m^2, according to the re-defined criteria of the World Health Organization for obesity in the Asia-Pacific region.[14] Based on the criteria of the World Health Organization, diabetes was defined as fasting plasma glucose of ≥126 mg/dL, a previous diagnosis of diabetes by a physician, or current use of anti-hyperglycaemic agents or insulin.[15] According to the criteria of the 7th Report of the Joint National Committee, hypertension was defined as an average SBP and/or DBP ≥140/90 mmHg or the use of anti-

hypertensive agents.[16] According to the guidelines for cholesterol of the NCEP ATP III, hypercholesterolemia was defined as a plasma total cholesterol of ≥240 mg/dL or current use of cholesterol-lowering agents.[17]

Statistical analysis

The demographic characteristics of the study participants are presented as the means ± SE or prevalence (SE). Comparisons of the characteristics across survey periods were performed using analysis of variance (ANOVA) or χ^2 test, as appropriate, and χ^2 linear trend test was also used. The relative index of inequality (RII), a measure of effect that permits meaningful comparisons of socioeconomic health inequalities over survey periods was computed. The RII enables direct comparisons between life-course SES variables with regard to the proportions of the population in different categories. To obtain the RII for each indicator of SES, a score between 0 (for the highest SES) and 1 (for the lowest SES) was assigned to each category based on the proportion of subjects above the midpoint in the category. For example, if 10% of the subjects were in the highest educational category, participants in the group were represented by the range 0–0.1 and given a score of 0.05 (half of 0.1). If 20% of the population were in the next group, participants in the group were given a score of 0.20 (0.1 plus 0.2/2). The RII was obtained by regressing the outcome on each of the SES scores and was directly interpretable for each SES indicator used to compare participants with lowest SES (1) with those with the highest SES (0). In this study, the RII of major CVD risk factors is presented using the odds ratio and 95% confidence interval computed from binary logistic regression analysis. Trends in the RII were estimated by including an interaction term for the SES indicator and a variable that identified the year of the data in the model. Significance

levels were set at a two-tailed p-value <0.05. All analyses were conducted using the SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

The general characteristics of participants in the KNHANES II (2001) to VI (2013-2014) are shown in Table 1. The mean age of participants increased over time (41.2 ± 0.2 to 43.8 ± 0.2 years and 41.6 ± 0.2 to 44.2 ± 0.2 years for men and women, respectively). The proportion of participants with college or higher education (≥13 years) increased gradually, from 39% to 47% for men and from 24% to 39% for women from 2001 to 2014.

Smoking

Over the past 14 years, smoking rate decreased significantly, from 65% to 47% in men, whereas it increased from 3.7% to 5.6% in women (Supplementary Table 1). Low SES was associated with a high prevalence of smoking in both genders (Table 2). Among Korean men, time trends in socioeconomic inequalities in smoking by education and income levels were generally stable during 2001-2014. In contrast, a significantly increasing trend in socioeconomic inequalities with regard to smoking was noted among women (Table 2).

Obesity

In men, there were significant increased trends of mean BMI (23.9 kg/m^2 in 2001 and 24.6 kg/m^2 in 2014, p <0.001) and the prevalence of obesity (34% for 2001 and 41% for 2014, p <

Table 1 General characteristics of the study population (25-64 years of age) from 2001 to 2014

	KNHANES*					P-value†
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14	
Men						
n	3164	2868	5318	5501	3315	
Age	41.2±0.2	41.1±0.3	42.4±0.2	43.1±0.2	43.8±0.2	<0.001
BMI	23.9±0.1	24.2±0.1	24.3±0.1	24.3±0.1	24.6±0.1	<0.001
Education (yr)						<0.001
≤6	9.4 (0.8)	8.3 (0.6)	9.6 (0.5)	8.3 (0.5)	7.2 (0.6)	
7-9	12.1 (0.7)	10.0 (0.7)	10.5 (0.5)	10.1 (0.5)	8.8 (0.6)	
10-12	39.8 (1.2)	42.4 (1.2)	39.4 (0.9)	38.6 (0.8)	36.9 (1.1)	
≥13	38.7 (1.6)	39.2 (1.4)	40.5 (1.0)	43.0 (0.9)	47.1 (1.2)	
Income‡						0.234
Q1	22.3 (1.3)	26.7 (1.2)	24.8 (0.8)	26.5 (0.8)	25.0 (1.0)	
Q2	24.0 (1.0)	25.2 (1.0)	24.2 (0.7)	25.6 (0.8)	26.0 (0.9)	
Q3	26.6 (1.0)	23.1 (0.9)	25.4 (0.7)	24.5 (0.7)	24.7 (0.9)	
Q4	27.0 (1.4)	25.0 (1.3)	25.7 (1.0)	23.5 (0.8)	24.2 (1.2)	
Women						
n	3509	3276	7048	7410	4497	
Age	41.6±0.3	41.6±0.3	42.7±0.2	43.5±0.2	44.2±0.2	<0.001
BMI	23.4±0.1	23.4±0.1	23.2±0.1	23.3±0.1	23.1±0.1	0.018
Education						<0.001
≤6	19.2 (1.1)	17.3 (0.9)	17.2 (0.6)	15.5 (0.6)	12.5 (0.7)	
7-9	14.6 (0.7)	13.2 (0.7)	12.3 (0.5)	11.6 (0.5)	10.2 (0.5)	
10-12	42.2 (1.1)	42.0 (1.3)	40.6 (0.7)	38.9 (0.8)	38.3 (0.9)	
≥13	24.1 (1.4)	27.6 (1.5)	29.9 (0.9)	34.0 (0.9)	39.1 (1.1)	
Income‡						0.133
Q1	23.1 (1.3)	25.9 (1.1)	24.3 (0.8)	27.6 (0.8)	24.7 (0.9)	
Q2	24.0 (0.9)	25.7 (1.0)	25.3 (0.7)	25.8 (0.7)	25.0 (0.9)	
Q3	26.1 (0.9)	24.2 (0.9)	25.2 (0.7)	24.4 (0.7)	25.1 (0.9)	
Q4	26.9 (1.5)	24.2 (1.3)	25.2 (0.9)	22.3 (0.7)	25.2 (1.2)	

Values given are n, prevalence (SE) or mean ± SE
*KNHANES (Korean National Health and Nutrition Examination Survey)
†P-value by ANOVA or χ^2test
‡Quartiles based on household income (10^4 KRW)

Table 2 Age-adjusted odds ratios (OR) and 95% confidence interval (CI) and relative indices of inequalities (RII) in smoking by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.75 (1.45-2.12)	1.86 (1.53-2.25)	1.57 (1.37-1.81)	1.47 (1.27-1.71)	1.48 (1.23-1.78)
7-9	1.48 (1.14-1.93)	1.57 (1.13-2.18)	2.16 (1.72-2.71)	1.62 (1.27-2.05)	1.25 (0.92-1.72)
≤6	2.41 (1.72-3.37)	2.22 (1.62-3.05)	1.95 (1.53-2.48)	1.71 (1.32-2.22)	1.77 (1.26-2.49)
RII (95% CI)	2.73 (1.97-3.79)	2.75 (2.00-3.79)	2.74 (2.16-3.48)	2.16 (1.69-2.77)	2.17 (1.57-3.00)
P for trend			0.193		
Income					
Q1	1	1	1	1	1
Q2	1.23 (0.97-1.55)	1.34 (1.05-1.72)	1.31 (1.11-1.56)	1.09 (0.91-1.30)	1.26 (1.00-1.59)
Q3	1.49 (1.17-1.91)	1.50 (1.21-1.86)	1.56 (1.32-1.85)	1.23 (1.01-1.49)	1.34 (1.07-1.66)
Q4	1.74 (1.35-2.24)	1.87 (1.46-2.40)	1.79 (1.51-2.12)	1.50 (1.24-1.81)	1.43 (1.15-1.79)
RII (95% CI)	2.10 (1.53-2.89)	2.22 (1.63-3.02)	2.16 (1.74-2.68)	1.71 (1.34-2.18)	1.57 (1.19-2.08)
P for trend			0.087		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.25 (0.75-2.09)	3.69 (2.07-6.57)	3.95 (2.78-5.62)	2.80 (1.97-4.00)	4.08 (2.67-6.22)
7-9	1.55 (0.76-3.15)	4.04 (1.95-8.34)	6.47 (3.90-10.7)	6.15 (3.65-10.4)	7.75 (4.12-14.6)
≤6	1.98 (1.00-3.90)	4.12 (1.92-8.86)	7.59 (4.42-13.0)	5.52 (3.06-9.9)	9.53 (4.88-18.6)
RII (95% CI)	1.75 (0.87-3.52)	3.41 (1.78-6.55)	8.27 (5.05-13.6)	6.81 (3.86-12.0)	10.29 (5.23-20.2)
P for trend			<0.001		
Income					
Q1	1	1	1	1	1
Q2	0.53 (0.29-0.95)	1.05 (0.58-1.91)	0.95 (0.64-1.42)	0.98 (0.66-1.46)	1.54 (0.82-2.89)
Q3	0.67 (0.39-1.13)	1.50 (0.90-2.51)	1.46 (1.02-2.09)	1.48 (0.99-2.23)	2.28 (1.29-4.00)
Q4	1.53 (0.95-2.47)	2.74 (1.68-4.46)	2.23 (1.57-3.17)	2.53 (1.75-3.65)	3.95 (2.34-6.66)
RII (95% CI)	1.92 (0.88-4.21)	4.45 (2.26-8.76)	3.36 (2.10-5.39)	4.11 (2.46-6.88)	6.27 (3.22-12.20)
P for trend			0.043		

0.001) over time (Table 1 and Supplementary Table 1). In contrast, women showed decreasing trends in mean BMI and the prevalence of obesity (23.4 kg/m^2 in 2001 and 23.1 kg/m^2 in 2014, p=0.018, 29% in 2001 and 25% in 2014, p=0.01; Table 1 and Supplementary Table 1). Time trends in socioeconomic inequalities in obesity were stable among men; however, a time trend toward increasing inequality in obesity by income was noted in women (1.72, 1.19-2.48 in 2001; 2.69, 2.02-3.59 in 2014, p=0.03, RII, 95% CI, respectively; Table 3).

Diabetes

In men, the prevalence of diabetes increased over time (6.8% in 2001, 10.4% in 2014, p <0.001). In contrast, the prevalence did not change significantly in women (Supplementary Table 1). Although no significant time trends in socioeconomic inequalities was seen in men, significantly increasing inequality in diabetes were noticed in women, especially by income (0.76, 0.36-1.58 in 2001; 2.56, 1.55-4.22 in 2014, RII, 95% CI, p=0.01, respectively; Table 4).

Hypertension

The prevalence of hypertension did not change significantly over time in either gender (Supplementary Table 1); however, there were gender differences in the time trend with regard to socioeconomic inequalities in hypertension (Table 5). In men, socioeconomic differences decreased with income over the past 14 years (1.64, 1.09-2.49 in 2001; 0.99, 0.71-1.39 in 2014, RII, 95% CI, p=0.04), whereas inequalities increased with marginal significance among women in the same period (1.48, 0.89-2.46 in 2001; 2.91, 1.98-4.29 in 2014, RII, 95% CI, p=0.06, by education; 1.22, 0.73-2.04 in 2001; 2.32, 1.63-3.30 in 2014, RII, 95% CI, p=0.056, by income, respectively; Table 5).

Table 3 Age-adjusted OR, 95% CI and RII in obesity by SES from 2001 to 2014

	KNHANES				
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	0.96 (0.78-1.20)	0.86 (0.66-1.12)	0.91 (0.79-1.04)	0.89 (0.76-1.04)	1.03 (0.86-1.23)
7-9	0.90 (0.64-1.26)	0.90 (0.57-1.44)	0.80 (0.65-1.00)	0.88 (0.67-1.14)	0.94 (0.68-1.30)
≤6	0.83 (0.55-1.23)	0.43 (0.27-0.67)	0.74 (0.58-0.93)	0.64 (0.48-0.84)	0.80 (0.57-1.11)
RII (95% CI)	0.95 (0.66-1.38)	0.63 (0.40-0.98)	0.74 (0.58-0.94)	0.79 (0.60-1.03)	0.98 (0.72-1.34)
P for trend			0.673		
Income					
Q1	1	1	1	1	1
Q2	1.15 (0.88-1.51)	0.89 (0.63-1.26)	1,02 (0.86-1.21)	0.89 (0.73-1.08)	0.90 (0.73-1.10)
Q3	0.92 (0.70-1.20)	0.71 (0.52-0.97)	1.02 (0.84-1.23)	0.97 (0.81-1.17)	1.15 (0.91-1.44)
Q4	1.11 (0.83-1.47)	0.76 (0.55-1.06)	0.96 (0.80-1.15)	0.74 (0.61-0.90)	0.85 (0.69-1.05)
RII (95% CI)	1.02 (0.71-1.45)	0.66 (0.43-1.02)	0.95 (0.75-1.20)	0.72 (0.57-0.92)	0.91 (0.70-1.20)
P for trend			0.778		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	2.64 (1.93-3.60)	1.99 (1.43-2.77)	1.74 (1.46-2.08)	1.90 (1.59-2.28)	1.76 (1.43-2.18)
7-9	5.53 (3.83-7.98)	2.84 (1.86-4.34)	2.49 (1.98-3.12)	2.45 (1.92-3.12)	2.92 (2.16-3.96)
≤6	3.79 (2.52-5.72)	3.42 (2.28-5.15)	3.55 (2.81-4.50)	2.65 (2.09-3.37)	3.99 (2.92-5.45)
RII (95% CI)	3.19 (2.23-4.57)	3.45 (2.17-5.47)	3.57 (2.83-4.51)	2.93 (2.29-3.73)	4.01 (2.94-5.49)
P for trend			0.617		
Income					
Q1	1	1	1	1	1
Q2	1.17 (0.90-1.51)	1.50 (1.06-2.11)	1.05 (0.87-1.26)	1.32 (1.07-1.63)	1.65 (1.29-2.10)
Q3	1.30 (0.97-1.73)	1.43 (1.03-1.98)	1.48 (1.24-1.77)	1.51 (1.25-1.83)	1.97 (1.58-2.47)
Q4	1.53 (1.15-2.03)	1.63 (1.16-2.29)	1.61 (1.34-1.93)	1.88 (1.54-2.29)	2.21 (1.74-2.81)
RII (95% CI)	1.72 (1.19-2.48)	1.73 (1.15-2.61)	2.03 (1.61-2.56)	2.21 (1.73-2.83)	2.69 (2.02-3.59)
P for trend			0.032		

Table 4 Age-adjusted OR, 95% CI and RII in diabetes by SES from 2005 to 2014

	KNHAENS			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education (yr)				
≥13	1	1	1	1
10-12	1.21 (0.72-2.03)	0.98 (0.74-1.28)	1.39 (1.05-1.85)	1.14 (0.82-1.57)
7-9	1.20 (0.64-2.25)	1.05 (0.73-1.52)	1.41 (0.96-2.06)	1.13 (0.71-1.81)
≤6	1.42 (0.77-2.59)	0.92 (0.64-1.32)	1.30 (0.88-1.90)	1.06 (0.65-1.73)
RII (95% CI)	1.41 (0.72-2.77)	0.91 (0.59-1.40)	1.38 (0.91-2.09)	1.09 (0.64-1.85)
P for trend		0.838		
Income				
Q1	1	1	1	1
Q2	0.53 (0.30-0.93)	1.12 (0.81-1.56)	0.76 (0.54-1.07)	0.86 (0.58-1.30)
Q3	0.84 (0.49-1.43)	0.96 (0.69-1.32)	0.90 (0.64-1.27)	1.06 (0.73-1.55)
Q4	0.93 (0.57-1.53)	1.48 (1.09-2.01)	1.06 (0.77-1.46)	1.34 (0.92-1.95)
RII (95% CI)	1.08 (0.53-2.18)	1.53 (1.02-2.30)	1.17 (0.76-1.79)	1.55 (0.95-2.56)
P for trend		0.557		
Women				
Education (yr)				
≥13	1	1	1	1
10-12	2.69 (1.11-6.53)	2.04 (1.28-3.23)	2.10 (1.30-3.40)	1.38 (0.89-2.12)
7-9	3.30 (1.00-10.9)	1.76 (1.02-3.05)	2.23 (1.26-3.96)	1.76 (1.02-3.02)
≤6	4.33 (1.42-13.3)	3.29 (1.93-5.59)	2.85 (1.62-5.02)	1.68 (0.99-2.87)
RII (95% CI)	3.69 (0.99-13.8)	3.33 (1.99-5.57)	2.61 (1.57-4.35)	1.92 (1.14-3.23)
P fortrend		0.254		
Income				
Q1	1	1	1	1
Q2	0.86 (0.46-1.59)	1.06 (0.70-1.59)	1.84 (1.21-2.79)	1.13 (0.72-1.78)
Q3	1.10 (0.62-1.98)	1.75 (1.23-2.50)	2.36 (1.55-3.57)	1.23 (0.79-1.91)
Q4	0.71 (0.39-1.31)	1.99 (1.39-2.87)	2.56 (1.72-3.82)	2.04 (1.38-3.01)
RII (95% CI)	0.76 (0.36-1.58)	2.80 (1.77-4.42)	2.90 (1.89-4.47)	2.56 (1.55-4.22)
P for trend		0.015		

Table 5 Age-adjusted OR, 95% CI and RII of hypertension by SES from 2001 to 2014

	KHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.43 (1.08-1.89)	1.03 (0.75-1.40)	1.03 (0.86-1.25)	1.15 (0.97-1.38)	0.97 (0.78-1.22)
7-9	1.22 (0.84-1.78)	1.50 (0.96-2.36)	0.98 (0.77-1.24)	1.12 (0.87-1.44)	0.93 (0.69-1.24)
≤6	1.17 (0.77-1.79)	1.31 (0.85-2.02)	1.08 (0.84-1.40)	1.15 (0.89-1.49)	1.01 (0.70-1.47)
RII (95% CI)	1.34 (0.88-2.03)	1.41 (0.90-2.20)	1.08 (0.82-1.42)	1.16 (0.88-1.52)	0.93 (0.66-1.32)
P for trend			0.133		
Income					
Q1	1	1	1	1	1
Q2	1.21 (0.86-1.69)	0.87 (0.59-1.29)	1.09 (0.88-1.35)	1.13 (0.91-1.42)	1.28 (0.95-1.71)
Q3	1.10 (0.76-1.59)	0.95 (0.70-1.29)	1.11 (0.89-1.39)	1.11 (0.89-1.37)	1.09 (0.83-1.43)
Q4	1.58 (1.14-2.19)	1.23 (0.90-1.69)	1.23 (0.99-1.54)	1.11 (0.89-1.38)	1.05 (0.80-1.39)
RII (95% CI)	1.64 (1.09-2.49)	1.37 (0.91-2.06)	1.30 (0.99-1.71)	1.11 (0.85-1.46)	0.99 (0.71-1.39)
P for trend			0.042		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.55 (0.93-2.61)	1.91 (1.14-3.18)	2.21 (1.62-3.02)	1.69 (1.32-2.17)	1.80 (1.30-2.47)
7-9	2.64 (1.47-4.76)	2.90 (1.60-5.25)	2.50 (1.76-3.55)	2.15 (1.58-2.92)	2.59 (1.78-3.77)
≤6	1.79 (0.99-3.24)	3.18 (1.68-5.99)	2.69 (1.91-3.80)	2.45 (1.83-3.30)	3.06 (2.10-4.46)
RII (95% CI)	1.48 (0.89-2.46)	2.11 (1.21-3.69)	1.93 (1.38-2.70)	2.15 (1.56-2.97)	2.91 (1.98-4.29)
P for trend			0.060		
Income					
Q1	1	1	1	1	1
Q2	1.48 (1.06-2.07)	1.37 (0.92-2.05)	0.99 (0.80-1.23)	1.04 (0.82-1.33)	1.44 (1.04-1.98)
Q3	1.15 (0.78-1.69)	1.33 (0.92-1.93)	1.25 (1.00-1.55)	1.29 (1.01-1.65)	2.33 (1.74-3.13)
Q4	1.29 (0.85-1.94)	1.50 (0.99-2.28)	1.39 (1.11-1.76)	1.41 (1.11-1.78)	1.73 (1.28-2.36)
RII (95% CI)	1.22 (0.73-2.04)	1.62 (0.97-2.71)	1.63 (1.20-2.22)	1.65 (1.23-2.21)	2.32 (1.63-3.30)
P for trend			0.056		

Hypercholesterolemia

The prevalence of hypercholesterolemia increased over time in both genders (Supplementary Table 1). However, there was no significant association between SES and hypercholesterolemia in either gender (Supplementary Table 2).

DISCUSSION

The result of this study reflected gender differences not only in the relationships between major CVD risk factors and SES, but also in the linear time trends in socioeconomic inequalities in major CVD risk factors among Koreans. Among men, no major CVD risk factors except smoking showed significant associations with SES. Indeed, socioeconomic inequalities in major CVD risk factors were stable over time and inequality in hypertension decreased over the past 14 years. However, women with a lower SES had higher risks of smoking, obesity, diabetes and hypertension than did those with a higher SES. Increasing trends in socioeconomic inequalities in smoking, obesity and diabetes, especially measured by income, were noted in Korean women. In contrast to the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequalities in either gender.

Socioeconomic inequalities in CVD risk factors and disease-related mortality are well known in Western industrialised countries and are now being found in many developing countries as well.[1-2, 18-19] However, there has been relatively little research examining time trends in socioeconomic inequalities in these CVD risk factors.[6-8] To our knowledge, this is the first report on trend in socioeconomic inequalities in major CVD risk factors in an Asian nations.

In this study, distinct gender differences in time trend in smoking rates were found between

Korean men and women, which is consistent with trends in other Asian countries, such as China and Taiwan.[20-21] Over the past 14 years, the smoking rate in men decreased, whereas, it increased in women. Consistent with previous reports, our study showed that Koreans with a lower SES had higher smoking rates than those with a higher SES in both genders.[22-23] However, our study further showed gender differences in the time trend of smoking inequality. Based on the RII trend, the trend in inequality was stable among men, but the socioeconomic gap among women widened. There has been significant progress with anti-smoking policies in Korea in recent years. In 1995, the Health Promotion Act was enacted and restricted smoking in public buildings and places. In 2004, a significant increase in taxation of tobacco products began.[24] We suspect that these policies may have been effective among men in all socioeconomic groups, but they were ineffective for women with a lower SES.

Over the past 14 years, the prevalence of obesity has increased in men, but it has decreased in women. Among men, SES was not associated with the prevalence of obesity; however, lower SES was associated with a higher prevalence of obesity in women, reflecting gender differences in attitudes towards body image in Korea.[25-26] A previous study reported that according to the recent International Health Behavior Survey of university students in 22 countries, the country with highest proportion of respondents who reported 'trying to lose weight' was Korea.[27] We also found increased socioeconomic inequality in obesity according to income in Korean women. This could be related to increased sensitivity about obesity in Korean women such that those who had financial ability may have engaged in weight- reduction efforts.

The prevalence of diabetes increased in men but showed no change in women during the

study period. Our study found gender differences in association between SES and the prevalence of diabetes, which is consistent with previous studies that reported the influence of SES on the risk of diabetes was more pronounced in women than in men.[19, 28-30] To our knowledge, there is no previous study investigating time trends in socioeconomic inequalities in diabetes in Koreans. The inequality in diabetes in women, measured by income, increased during the past 14 years, which is consistent with previous studies in other countries.[31-32] Although the reasons for this gender-related difference remain unclear, several plausible explanations that relate low SES to an increased risk of diabetes in women can be proposed. Socioeconomic inequalities may cause differing lifestyle behaviours, such as alcohol intake and physical activity. Women with a lower SES have higher risk of harmful alcohol consumption, smoking and lack of physical activity.[3, 33-34] It may also be related to less social support and poorer access to healthcare services, leading to lower level of the detection and treatment of diabetes and associated risk factors.[35] Finally, women with a lower SES may have poor eating habits, such as less intake of fruits and vegetables.[36]

During the study period, the prevalence of hypertension showed no change in either gender, however, the pattern of associations between SES and risk of hypertension differed by gender, which is consistent with a previous study.[37] The influence of low SES on hypertension was more prominent in women, socioeconomic inequalities widened with marginal statistical significance in women during study period. In contrast, the socioeconomic inequality in men was decreased, although the reason for alleviating inequality was not clear. One possible explanation is the diminished inequality with respect to smoking with marginal statistical significance in men during the study period.

Trends in socioeconomic inequalities in obesity and diabetes among women increased by

income level, but they were not significant when measured by education. Rapid social change has affected the meaning of education level; for example, the proportion of women who had an education level of college or above was 24% in KNHANES II (2001). However, it was ~40% in KNHANES VI (2013-2014). Thus, caution is needed in comparing education groups across time, especially in rapidly changing societies. Additionally, it may be better to divide education level into equal division to investigate health inequalities.[26, 38]

Two strengths of our study is that study subjects were a nationally representative sample and that time trends of the relationship between SES and five CVD major risk factors were examined using two SES measures (education level, household income). However, several limitations also be noted. First, the study was cross-sectional in nature; thus, it was difficult to determine causal relationships between SES and CVD risk factors. Second, the KNHANES is a self-report survey and therefore prone to measurement error and recall bias as well as heterogeneity in self-reported health. Third, the steady decline in response rates in the KNHANES should not be overlooked, although there has been no reported indication of potential selection bias from the KCDC.[39] Finally, we could not examine longer-term trends in socioeconomic inequalities in CVD risk factors before 2001, because, following the author' judgement, the KNHANES I (1998) survey data were excluded due to lack of reliability.

CONCLUSIONS

This study found that relationships between SES and major risk factors (smoking, obesity, diabetes, hypertension) were more prominent in Korean women than men. Inequalities,

especially measured by income, in smoking, obesity and diabetes increased among Korean women over the past 14 years. Public policies should be implemented to prevent those risk factors for CVD among Korean women with a lower SES.

Contributors YJK, SGK, JL and JSL developed the research questions and contributed to the development of the conceptual framework, and the interpretations of the results. YJK contributed to writing and submitting the manuscript. JSL performed the main analyses and critical revisions to the manuscript. JP provided theoretical support and DSC, DMK, KL and HYK assisted with writing the manuscript.

Funding No funding

Competing interests None declared.

Ethical approval All procedures and protocols of the study were approved by the institutional review board of Korea Centers for Disease Control and Prevention (KCDC) since 2007. Written informed consent regarding the survey and blood analysis has been obtained from all participants since 2001.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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Supplementary Table 1. Trends in prevalence (SE) of major risk factors of CVD from 2001 to 2014

	KNHANES					
	II	III	IV	V	VI	
	2001	2005	2007-9	2010-12	2013-14	P-value*
Men						
Smoking	65.3 (1.0)	55.5 (1.2)	49.5 (0.8)	49.7 (0.8)	46.8 (1.1)	<0.001
Obesity	33.9 (1.2)	37.8 (1.4)	39.6 (0.7)	38.7 (0.8)	41.4 (0.9)	<0.001
Diabetes	6.8 (0.6)	8.2 (0.6)	8.5 (0.4)	8.9 (0.5)	10.4 (0.6)	<0.001
Hypertension	25.4 (1.2)	25.2 (1.2)	22.5 (0.7)	26.2 (0.7)	26.4 (0.9)	0.36
Hypercholesterolemia	8.4 (0.7)	7.1 (0.7)	9.4 (0.5)	11.8 (0.5)	12.8 (0.7)	<0.001
Women						
Smoking	3.7 (0.4)	5.3 (0.5)	6.1 (0.4)	6.9 (0.4)	5.6 (0.5)	<0.001
Obesity	28.8 (1.0)	28.2 (1.2)	26.3 (0.6)	28.1 (0.7)	25.0 (0.8)	0.01
Diabetes	5.4 (0.5)	4.9 (0.6)	5.4 (0.3)	5.5 (0.3)	5.7 (0.4)	0.43
Hypertension	15.6 (0.9)	15.0 (0.9)	14,6 (0.5)	16.4 (0.6)	15.3 (0.6)	0.72
Hypercholesterolemia	8.3 (0.6)	6.3 (0.6)	9.7 (0.4)	12.8 (0.5)	12.8 (0.6)	<0.001

*P for χ^2 linear trend test

Supplementary Table 2. Age-adjusted OR, 95% CI and RII of hypercholesterolemia by SES from 2005 to 2014

	KNHANES			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education(yr)				
≥13	1	1	1	1
10-12	1.12 (0.68-1.82)	1.06 (0.82-1.36)	1.12 (0.88-1.43)	1.08 (0.81-1.42)
7-9	0.72 (0.29-1.79)	1.16 (0.80-1.69)	1.05 (0.77-1.44)	0.91 (0.54-1.52)
≤6	1.02 (0.55-1.91)	0.83 (0.57-1.23)	1.09 (0.74-1.60)	0.92 (0.58-1.45)
RII (95% CI)	0.89 (0.42-1.87)	1.00 (0.67-1.51)	1.14 (0.79-1.65)	0.93 (0.57-1.53)
P for trend			0.906	
Income				
Q4	1	1	1	1
Q3	0.54 (0.29-1.01)	0.86 (0.63-1.17)	0.64 (0.48-0.85)	1.15 (0.81-1.64)
Q2	0.87 (0.46-1.66)	0.88 (0.66-1.18)	0.97 (0.74-1.28)	0.81 (0.56-1.18)
Q1	0.98 (0.54-1.78)	1.02 (0.77-1.35)	0.93 (0.71-1.21)	0.85 (0.59-1.23)
RII (95% CI)	1.14 (0.48-2.72)	1.02 (0.71-1.48)	1.08 (0.76-1.54)	0.72 (0.45-1.14)
P for trend			0.301	
Women				
Education (yr)				
≥13	1	1	1	1
10-12	0.95 (0.47-0.91)	0.76 (0.56-1.02)	1.31 (0.99-1.73)	0.84 (0.62-1.15)
7-9	0.66 (0.30-1.44)	0.74 (0.52-1.05)	1.12 (0.80-1.56)	0.95 (0.63-1.43)
≤6	0.69 (0.31-1.57)	0.83 (0.58-1.19)	1.19 (0.84-1.67)	0.95 (0.63-1.43)
RII (95% CI)	0.64 (0.27-1.53)	0.85 (0.58-1.24)	1.08 (0.75-1.54)	0.85 (0.55-1.33)
P for trend			0.499	
Income				
Q4	1	1	1	1
Q3	0.82 (0.47-1.44)	0.88 (0.67-1.17)	0.98 (0.77-1.24)	0.79 (0.58-1.09)
Q2	0.65 (0.36-1.17)	0.97 (0.73-1.28)	0.93 (0.72-1.19)	1.29 (0.95-1.75)
Q1	0.96 (0.59-1.54)	1.08 (0.82-1.42)	1.12 (0.88-1.42)	1.02 (0.76-1.37)
RII (95% CI)	0.87 (0.44-1.70)	1.13 (0.79-1.61)	1.14 (0.84-1.54)	1.24 (0.85-1.81)
P for trend			0.397	

STROBE 2007 (v4)Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	*6-8*
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, 10,11
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-17
		(*b*) Report category boundaries when continuous variables were categorized	10-17
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

BMJ Open

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population (Korea National Health and Nutrition Examination Survey, 2001-2014): a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-014070.R1
Article Type:	Research
Date Submitted by the Author:	07-Dec-2016
Complete List of Authors:	Kim, Yoon Jung; Hallym University Kangdong Sacred Heart Hospital, Department of Internal Medicine Lee, Ji Sung; Asan Medical Center, University of Ulsan College of Medicine, Clinical Research Center Park, Juri; Hallym University Kangdong Sacred Heart Hospital, Division of Endocrinology and Metabolism, Department of Internal Medicine Choi, Dong Seop; Korea University College of Medicine, Department of Internal Medicine Kim, Doo Man; Hallym University Kangdong Sacred Heart Hospital, Division of Endocrinology and Metabolism, Department of Internal Medicine Lee, Kee-Hyoung ; Korea University College of Medicine, Pediatrics Kim, Ho Yeon ; Inha University Hospital, Department of Obstetrics and Gynecology Kim, Sin Gon; Korea University College of Medicine, Department of Internal Medicine Lee, Juneyoung; Korea University College of Medicine, Biostatistics
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, Health policy, Public health
Keywords:	Health inequality, cardiovascular disease, trend, cardiovascular disease risk factors

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population (Korea National Health and Nutrition Examination Survey, 2001-2014): a cross-sectional study

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Word count:

ABSTRACT

Objectives: To examine trends in socioeconomic inequalities in major cardiovascular disease (CVD) risk factors among Korean population

Design: Cross-sectional study

Setting: A nationally representative population survey database

Participants: A total of 42,725 Koreans, aged 25-64 years, using data from the Korean National Health and Nutrition Examination Survey II (2001) to VI (2013-2014)

Main outcome measures: Trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia)

Results Gender differences were noted in the time trends in socioeconomic inequalities in smoking, obesity, diabetes and hypertension. Among men, low SES was associated with higher prevalence of smoking, but not with those of obesity, diabetes or hypertension. The magnitudes of socioeconomic inequalities in smoking, obesity and diabetes remained unchanged, and the magnitude of the inequality in hypertension decreased over time. However, among women low SES was associated with higher prevalence of smoking, obesity, diabetes and hypertension. Time trends towards increasing socioeconomic inequalities, measured by income, in smoking, obesity and diabetes were found in women. Unlike the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequality.

Conclusions SES had a stronger impact on major CVD risk factors among Korean women than men. Moreover, socioeconomic inequalities in smoking, obesity and diabetes worsened

among Korean women over time. Public policies to prevent smoking, obesity and diabetes in women with lower SES are needed to address inequalities.

Keywords: trend, health inequality, cardiovascular disease, cardiovascular disease risk factors

Strengths and limitations of the study

- This study shows that socioeconomic inequalities in smoking, obesity and diabetes have been worsened over past 14 years among Korean women.
- A strength of this study is that nationally representative sample was used as a study population.
- The limitation of this study is that no more than fourteen years trend in socioeconomic inequalities can be examined because the data of KNHANES I (1998) was excluded due to its lack of reliability and there was no available nationally representative data before 1998.

INTRODUCTION

Socioeconomic status (SES) has shown inverse associations with cardiovascular disease (CVD) in most industrialised Western countries, such that disadvantaged groups experience higher risks for CVD.[1-2] A considerable portion of the association between SES and CVD has been attributed to the combined effects of inequalities in health-related behaviours, environmental conditions, social structures and contact with and delivery of healthcare services.[3] As CVD mortality and morbidity contribute sizeable proportions to overall health inequality, attempts to reduce these causes of death are public health concerns.[4] Previous studies have shown that a greater decline in the prevalence of CVD risk factors among higher SES groups widened the gap among SES groups over time in the US.[5-6] However, studies in England and Australia failed to provide strong evidence that socioeconomic inequalities in CVD risk factors had increased in recent decades.[7-8]

Korea, a recently developed country, has experienced rapid socioeconomic growth. The per capita gross national income has increased 2.5-fold over the past 14 years (from $11.000 US in 2001 to $27,000 US in 2014), but the gap in socioeconomic circumstances has widened during this period.[9-10] Thus, it remains unclear whether the increased overall wealth has improved health status of all segments of the population.

To our knowledge, no previous study has examined time trends in socioeconomic inequalities with regard to major CVD risk factors in Koreans. The purpose of this study was to examine recent national trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia) using national survey data by gender.

METHODS

Study participants

This study was based on data from five consecutive Korean National Health and Nutrition Examination Surveys (KNHANES) conducted from 2001 to 2014. A detailed description of the survey design and data collection in the KNHANES has been published before.[11] The KNHANES was initiated in 1998 and has been conducted as a series of surveys. We excluded the data from KNHANES I (1998) due to a lack of reliability.[12] Representative households of non-institutionalised Koreans residing in Korea were selected using a stratified and multi-stage clustered probability sampling method. The response rates in the target population ranged from 70.2% to 86.5%. In this study, the study population was limited to adults aged 25-64 years old to examine trends in socioeconomic inequalities. Considering the applicability of socioeconomic measures (such as education level and household income), we excluded survey participants aged younger than 25 who may not have completed their education or have no job and those older than 64 because they were mostly economically inactive. The total number of participants in the analysis was 42,725; 5,206 for the KNHANES II (2001), 4,286 for the KNHANES III (2005), 12,407 for the KNHANES IV (2007-2009), 12,977 for the KNHANES V (2010-2012), and 7,849 for the KNHANES VI (2013-2014) (Fig. 1). We composed the data set of 5 CVD risk factors individually excluding the data with missing values for each CVD risk factor.

Health interview and health examination survey

The KNHANES consists of three components: a health interview, a health examination, and a

nutrition survey. The health interview survey collects detailed information on SES (e.g. education level, household income), smoking and drinking behaviours, and healthcare utilisation. Prior diagnosis of diabetes and hypertension by a physician and current use of anti-hypertensive and anti-hyperglycaemic agents are included in the questionnaire. Height to the nearest 0.1 cm was measured using portable stadiometers. Weight to the nearest 0.1 kg was measured using a portable electronic scale. According to the standard protocol, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained nurses using a mercury sphygmomanometer (Baumanometer Desk model; Baum, NY, USA) on the right arm of the subject while sitting after at least 5 min of rest.

Blood sample collection and biochemical analysis

Venous blood samples were obtained from each participant in the morning after fasting for at least 8 h. All samples were processed according to the protocols of KNHANES. After blood collection, an 8-mL serum separating tube for analysing blood lipid level was kept at room temperature for 30 min, and the blood was subsequently centrifuged (3000 rpm, 15 min). A 2-ml sodium fluoride tube for analysing glucose levels was mixed in a roller mixer for 10 min. All blood samples were refrigerated at 2-8°C and then transported to the central laboratory. Within 24 h of blood collection, plasma concentrations of glucose and lipid were assayed using an Advia 1650 (Siemens, NY, USA) in 2005 and 2007 and using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) since 2008. Since 2005, all laboratory analyses were performed according to the protocol and monitored to ensure the values met acceptable standards of precision and reproducibility in a central laboratory. Because quality control for the biochemical analysis of blood was started by the Korea Centers for Disease Control and

Prevention (KCDC) in 2005, we analysed the data on serum glucose and total cholesterol that were collected since 2005 in this study.

Socioeconomic status (SES) indicators

Education level and income were used as SES indicators. Education level was grouped into four categories by years completed: college or higher (≥13 years), high school (10-12 years), middle school (7-9 years), elementary school or less (≤6 years). The measure of income was equivalised gross household income per month, defined as total household income divided by the square root of the number of household members to adjust for the effect of the number of individuals in the household. We divided study subjects into four groups according to quartiles of equivalised household income by gender and age (Q1–Q4; Q1, highest quartile; Q4, lowest quartile).

Definition of CVD risk factors

As for CVD risk factors, smoking, hypertension, diabetes mellitus and hypercholesterolemia were examined because these are major independent risk factors for cardiovascular disease.[13] Obesity was also included due to its role of predisposing factor that could enhance the impact of the four independent risk factors. Cigarette smoking was defined as a "yes" answer to both of the following questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as a BMI of ≥25 kg/m^2, according to the re-defined criteria of the World Health Organization for obesity

in the Asia-Pacific region.[14] Based on the criteria of the World Health Organization, diabetes was defined as fasting plasma glucose of ≥126 mg/dL, a previous diagnosis of diabetes by a physician, or current use of anti-hyperglycaemic agents or insulin.[15] According to the criteria of the 7th Report of the Joint National Committee, hypertension was defined as an average SBP and/or DBP ≥140/90 mmHg or the use of anti-hypertensive agents.[16] According to the guidelines for cholesterol of the NCEP ATP III, hypercholesterolemia was defined as a plasma total cholesterol of ≥240 mg/dL or current use of cholesterol-lowering agents.[17]

Statistical analysis

The demographic characteristics of the study participants are presented as the means ± SE or age-adjusted prevalence (SE). Comparisons of the characteristics across survey periods were performed using analysis of variance (ANOVA) or χ^2 test, as appropriate, and χ^2 linear trend test was also used. To adjust differences of results from change in age structure of each survey, age-adjusted prevalence was calculated using direct standardization method based on 2010 Korea Census. The relative index of inequality (RII), a measure of effect that permits meaningful comparisons of socioeconomic health inequalities over survey periods was computed. The RII enables direct comparisons between SES variables with regard to the proportions of the population in different categories. To obtain the RII for each indicator of SES, a score between 0 (for the highest SES) and 1 (for the lowest SES) was assigned to each category based on the proportion of subjects above the midpoint in the category. For example, if 10% of the subjects were in the highest educational category, participants in the group were represented by the range 0–0.1 and given a score of 0.05 (half of 0.1). If 20% of the

population were in the next group, participants in the group were given a score of 0.20 (0.1 plus 0.2/2). The RII was obtained by regressing the outcome on each of the SES scores and was directly interpretable for each SES indicator used to compare participants with lowest SES (1) with those with the highest SES (0). In this study, the RII of major CVD risk factors is presented using the odds ratio and 95% confidence interval computed from binary logistic regression analysis adjusted for age. Trends in the RII were examined by estimating the P value for an interaction term of SES indicator and the variables that identified the year of the data in the model. Survey year was entered into the model as a numerical value (e.g., 2001 for KNHANES II). As data from KNHANES were derived from stratified and multi-stage clustered probability sampling method to represent the entire South Korean population, population weightings were applied in the analyses. The PROC SURVEY procedure was used to apply stratification, primary sampling units and population weights. Significance levels were set at a two-tailed p-value <0.05. All analyses were conducted using the SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

The general characteristics of participants in the KNHANES II (2001) to VI (2013-2014) are shown in Table 1. The mean age of participants increased over time (41.2 ± 0.2 to 43.8 ± 0.2 years and 41.6 ± 0.2 to 44.2 ± 0.2 years for men and women, respectively). The proportion of participants with college or higher education (≥13 years) increased gradually, from 39% to 47% for men and from 24% to 39% for women from 2001 to 2014. There were significant interaction effects between gender and SES (education and income levels) on RII except for hypercholesterolemia. Specifically, p-values for gender by education interactions were for

Table 1 General characteristics of the study population (25-64 years) from 2001 to 2014

	KNHANES*					P-value†
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14	
Men						
n	3164	2868	5318	5501	3315	
Age	41.2±0.2	41.1±0.3	42.4±0.2	43.1±0.2	43.8±0.2	<0.001
BMI	23.9±0.1	24.2±0.1	24.3±0.1	24.3±0.1	24.6±0.1	<0.001
Education (yr)						<0.001
≤6	9.4 (0.8)	8.3 (0.6)	9.6 (0.5)	8.3 (0.5)	7.2 (0.6)	
7-9	12.1 (0.7)	10.0 (0.7)	10.5 (0.5)	10.1 (0.5)	8.8 (0.6)	
10-12	39.8 (1.2)	42.4 (1.2)	39.4 (0.9)	38.6 (0.8)	36.9 (1.1)	
≥13	38.7 (1.6)	39.2 (1.4)	40.5 (1.0)	43.0 (0.9)	47.1 (1.2)	
Income‡						0.234
Q1(highest)	22.3 (1.3)	26.7 (1.2)	24.8 (0.8)	26.5 (0.8)	25.0 (1.0)	
Q2	24.0 (1.0)	25.2 (1.0)	24.2 (0.7)	25.6 (0.8)	26.0 (0.9)	
Q3	26.6 (1.0)	23.1 (0.9)	25.4 (0.7)	24.5 (0.7)	24.7 (0.9)	
Q4(lowest)	27.0 (1.4)	25.0 (1.3)	25.7 (1.0)	23.5 (0.8)	24.2 (1.2)	
Prevalence§						
Smoking	64.0 (0.02)	54.8 (0.02)	49.0 (0.02)	49.7 (0.02)	47.1 (0.02)	0.03
Obesity	33.9 (0.02)	38.4 (0.02)	39.7 (0.02)	38.8 (0.02)	41.4 (0.02)	0.038
Diabetes	7.3 (0.01)	9.2 (0.01)	8.9 (0.01)	8.8 (0.01)	9.9 (0.01)	0.076
Hypertension	27.9 (0.02)	26.8 (0.01)	23.3 (0.01)	26.0 (0.01)	25.6 (0.01)	0.404
Hypercholesterolemia	8.6 (0.01)	7.4 (0.01)	9.5 (0.01)	11.7 (0.01)	12.6 (0.01)	0.062
Women						
n	3509	3276	7048	7410	4497	
Age	41.6±0.3	41.6±0.3	42.7±0.2	43.5±0.2	44.2±0.2	<0.001
BMI	23.4±0.1	23.4±0.1	23.2±0.1	23.3±0.1	23.1±0.1	0.018
Education						<0.001
≤6	19.2 (1.1)	17.3 (0.9)	17.2 (0.6)	15.5 (0.6)	12.5 (0.7)	
7-9	14.6 (0.7)	13.2 (0.7)	12.3 (0.5)	11.6 (0.5)	10.2 (0.5)	
10-12	42.2 (1.1)	42.0 (1.3)	40.6 (0.7)	38.9 (0.8)	38.3 (0.9)	
≥13	24.1 (1.4)	27.6 (1.5)	29.9 (0.9)	34.0 (0.9)	39.1 (1.1)	
Income‡						0.133
Q1(highest)	23.1 (1.3)	25.9 (1.1)	24.3 (0.8)	27.6 (0.8)	24.7 (0.9)	
Q2	24.0 (0.9)	25.7 (1.0)	25.3 (0.7)	25.8 (0.7)	25.0 (0.9)	
Q3	26.1 (0.9)	24.2 (0.9)	25.2 (0.7)	24.4 (0.7)	25.1 (0.9)	
Q4(lowest)	26.9 (1.5)	24.2 (1.3)	25.2 (0.9)	22.3 (0.7)	25.2 (1.2)	
Prevalence§						
Smoking	3.7 (0.01)	5.4 (0.01)	6.0 (0.01)	6.9 (0.01)	5.8 (0.01)	0.125
Obesity	30.8 (0.02)	29.7 (0.02)	26.8 (0.01)	28.0 (0.01)	24.4 (0.01)	0.036
Diabetes	5.9 (0.01)	5.3 (0.01)	5.7 (0.01)	5.4 (0.01)	5.4 (0.01)	0.177
Hypertension	17.7 (0.01)	16.9 (0.01)	15.3 (0.01)	16.1 (0.01)	14.2 (0.01)	0.034
Hypercholesterolemia	8.8 (0.01)	7.0 (0.01)	10.1 (0.01)	12.5 (0.01)	11.9 (0.01)	<0.001

Values given are n, prevalence (SE) or mean ± SE

*KNHANES (Korean National Health and Nutrition Examination Survey)
†P-value by ANOVA or χ^2test
‡Quartiles based on equivalised household income
§Age-adjusted prevalence

hypercholesterolemia. Specifically, p-values for gender by education interactions were <.001, <.001, .0002, <.0001 and .7679 for smoking, obesity, diabetes, hypertension and hypercholesterolemia, respectively. For gender by income interactions, they were <.001, <.001, .0326, .0484 and .3019, respectively. Therefore, we examined trends in socioeconomic inequalities in those major CVD risk factors by gender.

Smoking

Over the past 14 years, age-adjusted smoking rate decreased significantly, from 64% to 47% in men, but it did not change in women (Table 1). Low SES was associated with a high prevalence of smoking in both genders (Table 2). Among Korean men, time trends in socioeconomic inequalities in smoking by education and income levels were generally stable during 2001-2014. In contrast, a significantly increasing trend in socioeconomic inequalities with regard to smoking was noted among women (Table 2).

Obesity

We found significant increased trends in the mean BMI (23.9 kg/m^2 in 2001 and 24.6 kg/m^2 in 2014, p <0.001) and the age-adjusted prevalence of obesity (34% for 2001 and 41% for 2014, p=0.038) over time in men (Table 1). In contrast, women showed decreasing trends in mean BMI and the age-adjusted prevalence of obesity (23.4 kg/m^2 in 2001 and 23.1 kg/m^2 in 2014, p=0.018, 31% in 2001 and 24% in 2014, p=0.036; Table 1). Time trends in socioeconomic inequalities in obesity were stable among men; however, a time trend toward increasing inequality in obesity by income was noted in women (1.72, 1.19-2.48 in 2001;

Table 2 Age-adjusted odds ratios (OR) and 95% confidence interval (CI) and relative indices of inequalities (RII) in smoking by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.75 (1.45-2.12)	1.86 (1.53-2.25)	1.57 (1.37-1.81)	1.47 (1.27-1.71)	1.48 (1.23-1.78)
7-9	1.48 (1.14-1.93)	1.57 (1.13-2.18)	2.16 (1.72-2.71)	1.62 (1.27-2.05)	1.25 (0.92-1.72)
≤6	2.41 (1.72-3.37)	2.22 (1.62-3.05)	1.95 (1.53-2.48)	1.71 (1.32-2.22)	1.77 (1.26-2.49)
RII (95% CI)	2.73 (1.97-3.79)	2.75 (2.00-3.79)	2.74 (2.16-3.48)	2.16 (1.69-2.77)	2.17 (1.57-3.00)
P for trend			0.193		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.23 (0.97-1.55)	1.34 (1.05-1.72)	1.31 (1.11-1.56)	1.09 (0.91-1.30)	1.26 (1.00-1.59)
Q3	1.49 (1.17-1.91)	1.50 (1.21-1.86)	1.56 (1.32-1.85)	1.23 (1.01-1.49)	1.34 (1.07-1.66)
Q4(lowest)	1.74 (1.35-2.24)	1.87 (1.46-2.40)	1.79 (1.51-2.12)	1.50 (1.24-1.81)	1.43 (1.15-1.79)
RII (95% CI)	2.10 (1.53-2.89)	2.22 (1.63-3.02)	2.16 (1.74-2.68)	1.71 (1.34-2.18)	1.57 (1.19-2.08)
P for trend			0.087		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.25 (0.75-2.09)	3.69 (2.07-6.57)	3.95 (2.78-5.62)	2.80 (1.97-4.00)	4.08 (2.67-6.22)
7-9	1.55 (0.76-3.15)	4.04 (1.95-8.34)	6.47 (3.90-10.7)	6.15 (3.65-10.4)	7.75 (4.12-14.6)
≤6	1.98 (1.00-3.90)	4.12 (1.92-8.86)	7.59 (4.42-13.0)	5.52 (3.06-9.9)	9.53 (4.88-18.6)
RII (95% CI)	1.75 (0.87-3.52)	3.41 (1.78-6.55)	8.27 (5.05-13.6)	6.81 (3.86-12.0)	10.29 (5.23-20.2)
P for trend			<0.001		
Income					
Q1(highest)	1	1	1	1	1
Q2	0.53 (0.29-0.95)	1.05 (0.58-1.91)	0.95 (0.64-1.42)	0.98 (0.66-1.46)	1.54 (0.82-2.89)
Q3	0.67 (0.39-1.13)	1.50 (0.90-2.51)	1.46 (1.02-2.09)	1.48 (0.99-2.23)	2.28 (1.29-4.00)
Q4(lowest)	1.53 (0.95-2.47)	2.74 (1.68-4.46)	2.23 (1.57-3.17)	2.53 (1.75-3.65)	3.95 (2.34-6.66)
RII (95% CI)	1.92 (0.88-4.21)	4.45 (2.26-8.76)	3.36 (2.10-5.39)	4.11 (2.46-6.88)	6.27 (3.22-12.20)
P for trend			0.043		

2.69, 2.02-3.59 in 2014, p=0.03, RII, 95% CI, respectively; Table 3).

Diabetes

The age-adjusted prevalence of diabetes did not change significantly over time in either gender (Table 1). Although no significant time trend in socioeconomic inequality in diabetes was seen in men, significantly increasing inequality in diabetes was noticed in women, especially by income (0.76, 0.36-1.58 in 2001; 2.56, 1.55-4.22 in 2014, RII, 95% CI, p=0.01, respectively; Table 4).

Hypertension

The age-adjusted prevalence of hypertension did not change significantly over time among men (Table 1). However, the age-adjusted prevalence of hypertension was decreased over time among women. There were also gender differences in the time trend with regard to socioeconomic inequalities in hypertension (Table 5). In men, socioeconomic difference was decreased with income over the past 14 years (1.64, 1.09-2.49 in 2001; 0.99, 0.71-1.39 in 2014, RII, 95% CI, p=0.04), whereas inequalities were increased with marginal significance among women in the same period (1.48, 0.89-2.46 in 2001; 2.91, 1.98-4.29 in 2014, RII, 95% CI, p=0.06, by education; 1.22, 0.73-2.04 in 2001; 2.32, 1.63-3.30 in 2014, RII, 95% CI, p=0.056, by income, respectively; Table 5).

Hypercholesterolemia

Table 3 Age-adjusted OR, 95% CI and RII in obesity by SES from 2001 to 2014

	KNHANES				
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	0.96 (0.78-1.20)	0.86 (0.66-1.12)	0.91 (0.79-1.04)	0.89 (0.76-1.04)	1.03 (0.86-1.23)
7-9	0.90 (0.64-1.26)	0.90 (0.57-1.44)	0.80 (0.65-1.00)	0.88 (0.67-1.14)	0.94 (0.68-1.30)
≤6	0.83 (0.55-1.23)	0.43 (0.27-0.67)	0.74 (0.58-0.93)	0.64 (0.48-0.84)	0.80 (0.57-1.11)
RII (95% CI)	0.95 (0.66-1.38)	0.63 (0.40-0.98)	0.74 (0.58-0.94)	0.79 (0.60-1.03)	0.98 (0.72-1.34)
P for trend			0.673		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.15 (0.88-1.51)	0.89 (0.63-1.26)	1,02 (0.86-1.21)	0.89 (0.73-1.08)	0.90 (0.73-1.10)
Q3	0.92 (0.70-1.20)	0.71 (0.52-0.97)	1.02 (0.84-1.23)	0.97 (0.81-1.17)	1.15 (0.91-1.44)
Q4(lowest)	1.11 (0.83-1.47)	0.76 (0.55-1.06)	0.96 (0.80-1.15)	0.74 (0.61-0.90)	0.85 (0.69-1.05)
RII (95% CI)	1.02 (0.71-1.45)	0.66 (0.43-1.02)	0.95 (0.75-1.20)	0.72 (0.57-0.92)	0.91 (0.70-1.20)
P for trend			0.778		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	2.64 (1.93-3.60)	1.99 (1.43-2.77)	1.74 (1.46-2.08)	1.90 (1.59-2.28)	1.76 (1.43-2.18)
7-9	5.53 (3.83-7.98)	2.84 (1.86-4.34)	2.49 (1.98-3.12)	2.45 (1.92-3.12)	2.92 (2.16-3.96)
≤6	3.79 (2.52-5.72)	3.42 (2.28-5.15)	3.55 (2.81-4.50)	2.65 (2.09-3.37)	3.99 (2.92-5.45)
RII (95% CI)	3.19 (2.23-4.57)	3.45 (2.17-5.47)	3.57 (2.83-4.51)	2.93 (2.29-3.73)	4.01 (2.94-5.49)
P for trend			0.617		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.17 (0.90-1.51)	1.50 (1.06-2.11)	1.05 (0.87-1.26)	1.32 (1.07-1.63)	1.65 (1.29-2.10)
Q3	1.30 (0.97-1.73)	1.43 (1.03-1.98)	1.48 (1.24-1.77)	1.51 (1.25-1.83)	1.97 (1.58-2.47)
Q4(lowest)	1.53 (1.15-2.03)	1.63 (1.16-2.29)	1.61 (1.34-1.93)	1.88 (1.54-2.29)	2.21 (1.74-2.81)
RII (95% CI)	1.72 (1.19-2.48)	1.73 (1.15-2.61)	2.03 (1.61-2.56)	2.21 (1.73-2.83)	2.69 (2.02-3.59)
P for trend			0.032		

Table 4 Age-adjusted OR, 95% CI and RII in diabetes by SES from 2005 to 2014

	KNHAENS			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education (yr)				
≥13	1	1	1	1
10-12	1.21 (0.72-2.03)	0.98 (0.74-1.28)	1.39 (1.05-1.85)	1.14 (0.82-1.57)
7-9	1.20 (0.64-2.25)	1.05 (0.73-1.52)	1.41 (0.96-2.06)	1.13 (0.71-1.81)
≤6	1.42 (0.77-2.59)	0.92 (0.64-1.32)	1.30 (0.88-1.90)	1.06 (0.65-1.73)
RII (95% CI)	1.41 (0.72-2.77)	0.91 (0.59-1.40)	1.38 (0.91-2.09)	1.09 (0.64-1.85)
P for trend		0.838		
Income				
Q1(highest)	1	1	1	1
Q2	0.53 (0.30-0.93)	1.12 (0.81-1.56)	0.76 (0.54-1.07)	0.86 (0.58-1.30)
Q3	0.84 (0.49-1.43)	0.96 (0.69-1.32)	0.90 (0.64-1.27)	1.06 (0.73-1.55)
Q4(lowest)	0.93 (0.57-1.53)	1.48 (1.09-2.01)	1.06 (0.77-1.46)	1.34 (0.92-1.95)
RII (95% CI)	1.08 (0.53-2.18)	1.53 (1.02-2.30)	1.17 (0.76-1.79)	1.55 (0.95-2.56)
P for trend		0.557		
Women				
Education (yr)				
≥13	1	1	1	1
10-12	2.69 (1.11-6.53)	2.04 (1.28-3.23)	2.10 (1.30-3.40)	1.38 (0.89-2.12)
7-9	3.30 (1.00-10.9)	1.76 (1.02-3.05)	2.23 (1.26-3.96)	1.76 (1.02-3.02)
≤6	4.33 (1.42-13.3)	3.29 (1.93-5.59)	2.85 (1.62-5.02)	1.68 (0.99-2.87)
RII (95% CI)	3.69 (0.99-13.8)	3.33 (1.99-5.57)	2.61 (1.57-4.35)	1.92 (1.14-3.23)
P for trend		0.254		
Income				
Q1(highest)	1	1	1	1
Q2	0.86 (0.46-1.59)	1.06 (0.70-1.59)	1.84 (1.21-2.79)	1.13 (0.72-1.78)
Q3	1.10 (0.62-1.98)	1.75 (1.23-2.50)	2.36 (1.55-3.57)	1.23 (0.79-1.91)
Q4(lowest)	0.71 (0.39-1.31)	1.99 (1.39-2.87)	2.56 (1.72-3.82)	2.04 (1.38-3.01)
RII (95% CI)	0.76 (0.36-1.58)	2.80 (1.77-4.42)	2.90 (1.89-4.47)	2.56 (1.55-4.22)
P for trend		0.015		

Table 5 Age-adjusted OR, 95% CI and RII of hypertension by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.43 (1.08-1.89)	1.03 (0.75-1.40)	1.03 (0.86-1.25)	1.15 (0.97-1.38)	0.97 (0.78-1.22)
7-9	1.22 (0.84-1.78)	1.50 (0.96-2.36)	0.98 (0.77-1.24)	1.12 (0.87-1.44)	0.93 (0.69-1.24)
≤6	1.17 (0.77-1.79)	1.31 (0.85-2.02)	1.08 (0.84-1.40)	1.15 (0.89-1.49)	1.01 (0.70-1.47)
RII (95% CI)	1.34 (0.88-2.03)	1.41 (0.90-2.20)	1.08 (0.82-1.42)	1.16 (0.88-1.52)	0.93 (0.66-1.32)
P for trend			0.133		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.21 (0.86-1.69)	0.87 (0.59-1.29)	1.09 (0.88-1.35)	1.13 (0.91-1.42)	1.28 (0.95-1.71)
Q3	1.10 (0.76-1.59)	0.95 (0.70-1.29)	1.11 (0.89-1.39)	1.11 (0.89-1.37)	1.09 (0.83-1.43)
Q4(lowest)	1.58 (1.14-2.19)	1.23 (0.90-1.69)	1.23 (0.99-1.54)	1.11 (0.89-1.38)	1.05 (0.80-1.39)
RII (95% CI)	1.64 (1.09-2.49)	1.37 (0.91-2.06)	1.30 (0.99-1.71)	1.11 (0.85-1.46)	0.99 (0.71-1.39)
P for trend			0.042		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.55 (0.93-2.61)	1.91 (1.14-3.18)	2.21 (1.62-3.02)	1.69 (1.32-2.17)	1.80 (1.30-2.47)
7-9	2.64 (1.47-4.76)	2.90 (1.60-5.25)	2.50 (1.76-3.55)	2.15 (1.58-2.92)	2.59 (1.78-3.77)
≤6	1.79 (0.99-3.24)	3.18 (1.68-5.99)	2.69 (1.91-3.80)	2.45 (1.83-3.30)	3.06 (2.10-4.46)
RII (95% CI)	1.48 (0.89-2.46)	2.11 (1.21-3.69)	1.93 (1.38-2.70)	2.15 (1.56-2.97)	2.91 (1.98-4.29)
P for trend			0.060		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.48 (1.06-2.07)	1.37 (0.92-2.05)	0.99 (0.80-1.23)	1.04 (0.82-1.33)	1.44 (1.04-1.98)
Q3	1.15 (0.78-1.69)	1.33 (0.92-1.93)	1.25 (1.00-1.55)	1.29 (1.01-1.65)	2.33 (1.74-3.13)
Q4(lowest)	1.29 (0.85-1.94)	1.50 (0.99-2.28)	1.39 (1.11-1.76)	1.41 (1.11-1.78)	1.73 (1.28-2.36)
RII (95% CI)	1.22 (0.73-2.04)	1.62 (0.97-2.71)	1.63 (1.20-2.22)	1.65 (1.23-2.21)	2.32 (1.63-3.30)
P for trend			0.056		

The age-adjusted prevalence of hypercholesterolemia among men increased with marginal statistical significance. The age-adjusted prevalence of hypercholesterolemia among women increased over time (Table 1). There was no significant association between

SES and hypercholesterolemia in either gender (Table 6).

DISCUSSION

The result of this study reflected gender differences not only in the relationships between major CVD risk factors and SES, but also in the linear time trends in socioeconomic inequalities in major CVD risk factors among Koreans. Among men, no major CVD risk factor except smoking showed significant associations with SES. Indeed, socioeconomic inequalities in major CVD risk factors were stable over time and inequality in hypertension decreased over the past 14 years. However, women with a lower SES had higher risks of smoking, obesity, diabetes and hypertension than did those with a higher SES. Increasing trends in socioeconomic inequalities in smoking, obesity and diabetes, especially measured

major CVD risk factors and SES, but also in the linear time trends in socioeconomic inequalities in major CVD risk factors among Koreans. Among men, no major CVD risk factor except smoking showed significant associations with SES. Indeed, socioeconomic inequalities in major CVD risk factors were stable over time and inequality in hypertension decreased over the past 14 years. However, women with a lower SES had higher risks of smoking, obesity, diabetes and hypertension than did those with a higher SES. Increasing trends in socioeconomic inequalities in smoking, obesity and diabetes, especially measured by income, were noted in Korean women. In contrast to the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequalities in either gender. Socioeconomic inequalities in CVD risk factors and disease-related mortality are well known

Table 6 Age-adjusted OR, 95% CI and RII of hypercholesterolemia by SES from 2005 to 2014

	KNHANES			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education(yr)				
≥13	1	1	1	1
10-12	1.12 (0.68-1.82)	1.06 (0.82-1.36)	1.12 (0.88-1.43)	1.08 (0.81-1.42)
7-9	0.72 (0.29-1.79)	1.16 (0.80-1.69)	1.05 (0.77-1.44)	0.91 (0.54-1.52)
≤6	1.02 (0.55-1.91)	0.83 (0.57-1.23)	1.09 (0.74-1.60)	0.92 (0.58-1.45)
RII (95% CI)	0.89 (0.42-1.87)	1.00 (0.67-1.51)	1.14 (0.79-1.65)	0.93 (0.57-1.53)
P for trend			0.906	
Income				
Q1 (highest)	1	1	1	1
Q2	0.54 (0.29-1.01)	0.86 (0.63-1.17)	0.64 (0.48-0.85)	1.15 (0.81-1.64)
Q3	0.87 (0.46-1.66)	0.88 (0.66-1.18)	0.97 (0.74-1.28)	0.81 (0.56-1.18)
Q4 (lowest)	0.98 (0.54-1.78)	1.02 (0.77-1.35)	0.93 (0.71-1.21)	0.85 (0.59-1.23)
RII (95% CI)	1.14 (0.48-2.72)	1.02 (0.71-1.48)	1.08 (0.76-1.54)	0.72 (0.45-1.14)
P for trend			0.301	
Women				
Education (yr)				
≥13	1	1	1	1
10-12	0.95 (0.47-0.91)	0.76 (0.56-1.02)	1.31 (0.99-1.73)	0.84 (0.62-1.15)
7-9	0.66 (0.30-1.44)	0.74 (0.52-1.05)	1.12 (0.80-1.56)	0.95 (0.63-1.43)
≤6	0.69 (0.31-1.57)	0.83 (0.58-1.19)	1.19 (0.84-1.67)	0.95 (0.63-1.43)
RII (95% CI)	0.64 (0.27-1.53)	0.85 (0.58-1.24)	1.08 (0.75-1.54)	0.85 (0.55-1.33)
P for trend			0.499	
Income				
Q1 (highest)	1	1	1	1
Q2	0.82 (0.47-1.44)	0.88 (0.67-1.17)	0.98 (0.77-1.24)	0.79 (0.58-1.09)
Q3	0.65 (0.36-1.17)	0.97 (0.73-1.28)	0.93 (0.72-1.19)	1.29 (0.95-1.75)
Q4 (lowest)	0.96 (0.59-1.54)	1.08 (0.82-1.42)	1.12 (0.88-1.42)	1.02 (0.76-1.37)
RII (95% CI)	0.87 (0.44-1.70)	1.13 (0.79-1.61)	1.14 (0.84-1.54)	1.24 (0.85-1.81)
P for trend			0.397	

in Western industrialised countries and are now being found in many developing countries as well.[1-2, 18-19] However, there has been relatively little research examining time trends in socioeconomic inequalities in these CVD risk factors.[6-8] To our knowledge, this is the first report on trends in socioeconomic inequalities in major CVD risk factors in an Asian nation.

In this study, distinct gender differences in time trend in smoking rates were found between Korean men and women, which is consistent with trends in other Asian countries, such as China and Taiwan.[20-21] Over the past 14 years, the smoking rate in men decreased, but that among women did not change significantly. Consistent with previous reports, our study showed that Koreans with a lower SES had higher smoking rates than those with a higher SES in both genders.[22-23] However, our study further showed gender differences in the time trend of smoking inequality. Based on the RII trend, the trend in inequality was stable among men, but the socioeconomic gap among women widened. There has been significant progress with anti-smoking policies in Korea in recent years. In 1995, the Health Promotion Act was enacted and restricted smoking in public buildings and places. In 2004, a significant increase in taxation of tobacco products began.[24] We suspect that these policies may have been effective among men in all socioeconomic groups, but they were ineffective for women with lower SES.

Over the past 14 years, the prevalence of obesity has increased in men, but it has decreased in women. Among men, SES was not associated with the prevalence of obesity; however, lower SES was associated with a higher prevalence of obesity in women, reflecting gender differences in attitudes towards body image in Korea.[25] Men and women could have different attitudes toward body weight status and may use different methods for controlling body weight. As societies develop, women tend to acquire a more negative attitude toward

obesity than do men. Additionally, public attitudes are more strongly negative towards obese women than towards obese men. Thus, women are more likely to use their resources to pursue a thinner body than are men, and women tend to shift their diet and activity patterns to a healthier lifestyle more rapidly than do men.[26-27]

The prevalence of diabetes did not change in either gender during the study period. Our study found gender differences in association between SES and the prevalence of diabetes, which is consistent with previous studies that reported the influence of SES on the risk of diabetes was more pronounced in women than in men.[19, 28-30] To our knowledge, there is no previous study investigating time trends in socioeconomic inequalities in diabetes in Koreans. The inequality in diabetes in women, measured by income, increased during the past 14 years, which is consistent with previous studies in other countries.[31-32] Although the reasons for this gender-related difference remain unclear, several plausible explanations that relate low SES to an increased risk of diabetes in women can be proposed. Socioeconomic inequalities may cause differing lifestyle behaviours, such as alcohol intake and physical activity. Women with a lower SES have higher risk of harmful alcohol consumption, smoking and lack of physical activity.[3, 33-34] It may also be related to less social support and poorer access to healthcare services, leading to lower level of the detection and treatment of diabetes and associated risk factors.[35] Finally, women with a lower SES may have poor eating habits, such as less intake of fruits and vegetables.[36]

During the study period, the prevalence of hypertension did not change among men, but decreased among women. The pattern of associations between SES and risk of hypertension differed by gender, which is consistent with a previous study.[37] The influence of low SES on hypertension was more prominent and socioeconomic inequalities widened with marginal

statistical significance in women during study period. In contrast, the socioeconomic inequality in men was decreased, although the reason for alleviating inequality was not clear. One possible explanation is that the marginally significant diminished inequality with respect to smoking in men during the study period may have mitigated the inequality.

Trends in socioeconomic inequalities in obesity and diabetes among women increased by income level, but they were not significant when measured by education. Rapid social change has affected the meaning of education level; for example, the proportion of women who had an education level of college or above was 24% in KNHANES II (2001). However, it was ~40% in KNHANES VI (2013-2014). Thus, caution is needed in comparing education groups across time, especially in rapidly changing societies. Additionally, it may be better to divide education level into equal division to investigate health inequalities.[26, 38]

Investigating the trends of RIIs were commonly used method for relative measures, but some cases, absolute and relative measures may diverge with respect to magnitude or direction of change in health inequalities.[39] Therefore we also examined the slope index of inequalities (SII) as absolute measures of inequalities for five major CVD risk factors, and found no difference in trends between relative and absolute inequalities (Supplementary table 1-5).

Two strengths of our study is that study subjects were a nationally representative sample and that time trends of the relationship between SES and five CVD major risk factors were examined using two SES measures (education level, household income). However, several limitations also be noted. First, the study was cross-sectional in nature; thus, it was difficult to determine causal relationships between SES and CVD risk factors. Second, the KNHANES is a self-report survey and therefore prone to measurement error and recall bias as well as heterogeneity in self-reported health. Third, the steady decline in response rates in the

KNHANES should not be overlooked, which could result in underestimating inequalities.[40] Finally, we could not examine longer-term trends in socioeconomic inequalities in CVD risk factors before 2001, because, following the authors' judgement, the KNHANES I (1998) survey data were excluded due to lack of reliability.

CONCLUSIONS

This study found that relationships between SES and major CVD risk factors (smoking, obesity, diabetes, hypertension) were more prominent in Korean women than men. Health inequalities, especially measured by income, in smoking, obesity and diabetes increased among Korean women over the past 14 years. Public policies should be implemented to prevent those risk factors for CVD among Korean women with a lower SES.

Contributors YJK, SGK, JL and JSL developed the research questions and contributed to the development of the conceptual framework, and the interpretations of the results. YJK contributed to writing and submitting the manuscript. JSL performed the main analyses and critical revisions to the manuscript. JP provided theoretical support and DSC, DMK, KL and HYK assisted with writing the manuscript.

Funding No funding

Competing interests None declared.

Ethical approval All procedures and protocols of the study were approved by the institutional review board of Korea Centers for Disease Control and Prevention (KCDC)

since 2007. Written informed consent regarding the survey and blood analysis has been obtained from all participants since 2001.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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Figure legends

Fig 1. Study enrollment

Enrolled study population from the Korean National Health and Nutrition Examination survey (KNHANES) 2001-2014

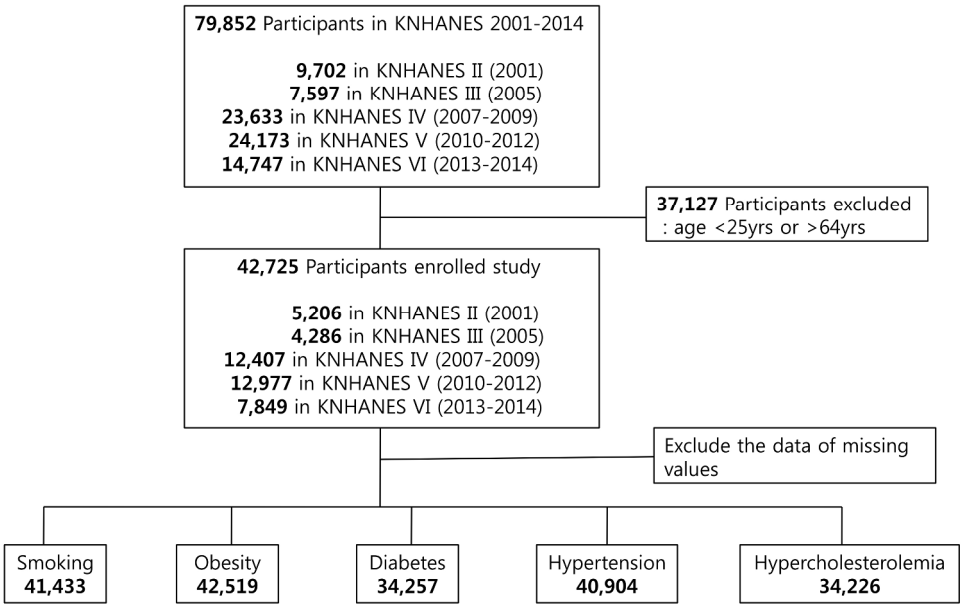

Figure 1

Fig 1. Study enrollment; ┬ ┼ Enrolled study population from the Korean National Health and Nutrition Examination survey (KNHANES) 2001-2014
The total number of participan
254x190mm (300 x 300 DPI)

STROBE 2007 (v4)Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-8
Bias	9	Describe any efforts to address potential sources of bias	*6-8*
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-8
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9
		(*b*) Describe any methods used to examine subgroups and interactions	
		(*c*) Explain how missing data were addressed	
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6, 10,11
		(b) Give reasons for non-participation at each stage	
		(c) Consider use of a flow diagram	
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	10,11
		(b) Indicate number of participants with missing data for each variable of interest	
Outcome data	15*	Report numbers of outcome events or summary measures	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-17
		(*b*) Report category boundaries when continuous variables were categorized	10-17
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	17
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	20
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	20
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	21

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Supplementary table 1. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of smoking by SES from 2001 to 2014

		KNHAENS II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	56.65(56.58-56.73)	46.60(46.53-46.67)	41.99(41.94-42.05)	42.64(42.58-42.69)	41.90(41.85-41.95)
	10-12	68.60(68.52-68.68)	59.23(59.17-59.29)	51.71(51.65-51.77)	53.57(53.50-53.63)	52.58(52.51-52.64)
	7-9	67.43(67.27-67.58)	58.22(57.99-58.45)	63.60(63.37-63.84)	62.96(62.74-63.18)	44.92(44.73-45.12)
	≤6	62.61(62.34-62.88)	51.23(50.90-51.56)	70.01(69.60-70.43)	45.81(45.56-46.06)	64.38(63.91-64.85)
	SII	9.83	8.98	36.53	13.72	20.49
	P for SII trend			0.454		
Income	Q1 (highest)	57.16(57.08-57.24)	47.07(47.00-47.14)	41.17(41.11-41.24)	45.32(45.24-45.39)	42.06(41.99-42.13)
	Q2	62.02(61.93-62.10)	53.96(53.88-54.04)	47.86(47.79-47.93)	47.06(46.98-47.13)	47.44(47.37-47.51)
	Q3	67.39(67.29-67.48)	56.25(56.17-56.33)	52.02(51.94-52.09)	50.25(50.18-50.32)	48.59(48.52-48.67)
	Q4 (lowest)	70.45(70.35-70.56)	62.14(62.05-62.22)	55.48(55.40-55.56)	55.07(54.99-55.14)	50.06(49.99-50.14)
	SII	17.96	19.08	18.92	12.99	9.98
	P for SII linear trend			0.105		
Women						
Education(yr)	≥13	2.91(2.88-2.95)	2.47(2.44-2.49)	2.82(2.80-2.84)	4.30(4.27-4.32)	2.61(2.60-2.63)
	10-12	2.85(2.84-2.87)	6.53(6.51-6.55)	7.50(7.48-7.52)	8.82(8.79-8.85)	8.24(8.21-8.27)
	7-9	3.42(3.39-3.45)	9.15(9.04-9.26)	13.22(13.12-13.33)	26.92(26.73-27.12)	19.35(19.21-19.49)
	≤6	2.62(2.60-2.64)	5.31(5.25-5.36)	15.22(15.03-15.41)	13.11(12.92-13.29)	15.08(14.89-15.27)
	SII	-0.01	5.27	16.69	20.27	20.55
	P for SII trend			0.009		
Income	Q1 (highest)	3.47(3.45-3.49)	3.50(3.48-3.52)	4.24(4.21-4.26)	4.69(4.66-4.71)	2.81(2.79-2.83)
	Q2	2.36(2.34-2.37)	3.94(3.91-3.96)	4.12(4.10-4.14)	4.55(4.53-4.58)	4.41(4.39-4.44)
	Q3	2.80(2.78-2.82)	5.20(5.18-5.23)	6.07(6.04-6.10)	6.80(6.78-6.83)	6.12(6.10-6.15)
	Q4 (lowest)	6.62(6.59-6.66)	9.03(8.99-9.06)	9.01(8.97-9.04)	10.88(10.84-10.91)	10.07(10.04-10.11)
	SII	3.82	7.22	6.48	8.39	9.38
	P for SII linear trend			0.047		

Supplementary table 2. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of obesity by SES from 2001 to 2014

		KNHAES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	36.40(36.34-36.47)	39.99(39.92-40.06)	41.78(41.72-41.84)	40.84(40.78-40.90)	41.37(41.31-41.42)
	10-12	33.08(33.03-33.13)	37.94(37.89-38.00)	39.87(39.81-39.92)	38.83(38.78-38.88)	42.05(41.99-42.11)
	7-9	33.23(33.14-33.33)	45.11(44.93-45.29)	41.27(41.09-41.45)	40.33(40.17-40.49)	32.90(32.75-33.05)
	≤6	28.58(28.44-28.73)	17.16(17.09-17.23)	41.24(40.95-41.54)	28.98(28.74-29.21)	47.57(47.15-47.99)
	SII	-8.22	-16.56	-0.50	-10.54	0.08
	P for SII trend			0.542		
Income	Q1 (highest)	33.88(33.82-33.95)	42.86(42.79-42.93)	40.04(39.97-40.10)	41.71(41.64-41.78)	42.22(42.16-42.29)
	Q2	35.44(35.38-35.51)	40.01(39.94-40.08)	40.50(40.44-40.57)	38.90(38.83-38.96)	39.38(39.32-39.45)
	Q3	31.99(31.93-32.06)	34.15(34.08-34.21)	40.24(40.17-40.31)	40.86(40.79-40.92)	45.56(45.49-45.62)
	Q4 (lowest)	34.33(34.26-34.40)	35.43(35.36-35.49)	38.98(38.91-39.05)	34.46(34.40-34.52)	38.45(38.39-38.51)
	SII	-0.88	-11.40	-1.36	-7.97	-2.05
	P for SII linear trend			0.940		
Women						
Education(yr)	≥13	18.04(17.94-18.14)	19.07(18.92-19.22)	16.70(16.64-16.76)	18.90(18.85-18.96)	16.07(16.03-16.11)
	10-12	29.99(29.92-30.05)	28.80(28.74-28.86)	24.77(24.72-24.81)	29.91(29.86-29.96)	24.32(24.27-24.36)
	7-9	49.81(49.65-49.98)	35.23(35.12-35.33)	31.40(31.28-31.52)	36.96(36.80-37.12)	32.23(32.08-32.38)
	≤6	38.00(37.84-38.15)	34.50(34.39-34.62)	42.94(42.71-43.18)	35.07(34.88-35.26)	50.83(50.49-51.16)
	SII	32.50	21.32	31.76	23.51	40.66
	P for SII trend			0.487		
Income	Q1 (highest)	27.20(27.14-27.26)	23.77(23.72-23.82)	22.51(22.46-22.56)	21.61(21.56-21.66)	16.17(16.13-16.21)
	Q2	30.01(29.94-30.07)	31.52(31.46-31.58)	23.51(23.46-23.56)	26.58(26.52-26.63)	24.04(23.99-24.09)
	Q3	31.30(31.24-31.37)	30.89(30.83-30.95)	29.79(29.74-29.85)	29.19(29.14-29.25)	27.61(27.55-27.66)
	Q4 (lowest)	34.96(34.88-35.03)	33.07(33.00-33.13)	31.65(31.59-31.71)	33.72(33.66-33.78)	29.87(29.81-29.93)
	SII	9.76	10.78	13.43	15.53	17.86
	P for SII linear trend			0.023		

Supplementary table 3. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of diabetes by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	8.09(8.05-8.12)	8.26(8.23-8.29)	7.29(7.27-7.32)	8.87(8.85-8.90)
	10-12	9.43(9.40-9.47)	8.89(8.86-8.92)	9.49(9.47-9.52)	10.32(10.29-10.35)
	7-9	11.27(11.20-11.35)	10.10(10.04-10.15)	9.09(9.04-9.14)	14.18(14.07-14.29)
	≤6	10.20(10.15-10.26)	7.60(7.55-7.65)	11.06(10.92-11.19)	9.42(9.36-9.49)
	SII	3.56	0.41	4.13	3.66
	P for SII trend		0.602		
Income	Q1 (highest)	10.35(10.32-10.39)	7.94(7.91-7.97)	9.27(9.24-9.31)	9.52(9.49-9.55)
	Q2	6.61(6.58-6.64)	8.60(8.56-8.63)	7.29(7.26-7.31)	8.14(8.11-8.17)
	Q3	9.00(8.96-9.03)	7.83(7.80-7.86)	8.62(8.59-8.65)	9.81(9.77-9.84)
	Q4 (lowest)	10.38(10.34-10.42)	11.35(11.31-11.39)	9.77(9.74-9.80)	12.17(12.13-12.21)
	SII	1.05	3.75	1.16	3.83
	P for SII linear trend		0.576		
Women					
Education(yr)	≥13	0.58(0.58-0.59)	2.81(2.78-2.84)	3.80(3.76-3.83)	3.86(3.83-3.89)
	10-12	5.75(5.72-5.78)	5.15(5.13-5.18)	5.49(5.47-5.52)	5.64(5.62-5.67)
	7-9	7.65(7.59-7.70)	5.32(5.28-5.36)	5.04(5.00-5.07)	7.45(7.38-7.52)
	≤6	7.17(7.14-7.21)	9.16(9.08-9.23)	8.14(8.05-8.23)	7.34(7.27-7.41)
	SII	8.92	7.00	4.55	5.06
	P for SII trend		0.048		
Income	Q1 (highest)	6.11(6.08-6.14)	3.94(3.92-3.96)	2.85(2.83-2.87)	4.30(4.28-4.32)
	Q2	5.11(5.08-5.13)	4.16(4.14-4.19)	4.93(4.90-4.95)	4.60(4.58-4.63)
	Q3	6.41(6.38-6.44)	6.71(6.68-6.74)	6.36(6.33-6.38)	5.06(5.04-5.09)
	Q4 (lowest)	4.41(4.39-4.44)	7.51(7.47-7.54)	6.86(6.83-6.89)	7.89(7.86-7.92)
	SII	-1.51	5.26	5.31	4.45
	P for SII linear trend		0.016		

Supplementary table 4. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypertension by SES from 2001 to 2014

		KNHANES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	24.86(24.80-24.92)	24.71(24.65-24.77)	22.62(22.57-22.67)	24.67(24.62-24.72)	25.26(25.22-25.31)
	10-12	30.59(30.54-30.65)	25.85(25.80-25.90)	23.53(23.49-23.58)	27.11(27.07-27.16)	25.21(25.16-25.25)
	7-9	28.27(28.19-28.36)	27.05(26.96-27.13)	21.94(21.87-22.01)	24.90(24.80-25.00)	23.66(23.54-23.78)
	≤6	28.18(28.04-28.31)	25.04(24.95-25.13)	24.74(24.62-24.86)	29.11(28.92-29.31)	28.45(28.24-28.67)
	SII	3.96	1.52	1.37	3.75	1.79
	P for SII trend			0.888		
Income	Q1 (highest)	24.27(24.21-24.33)	26.31(26.25-26.36)	21.65(21.60-21.70)	24.42(24.37-24.47)	23.56(23.51-23.61)
	Q2	27.83(27.77-27.89)	24.85(24.79-24.91)	23.07(23.01-23.12)	27.03(26.98-27.09)	28.41(28.36-28.47)
	Q3	26.58(26.51-26.64)	25.99(25.93-26.05)	23.47(23.42-23.52)	26.46(26.41-26.52)	25.31(25.26-25.36)
	Q4 (lowest)	32.14(32.07-32.21)	30.63(30.57-30.70)	25.38(25.32-25.43)	26.39(26.34-26.44)	24.76(24.70-24.81)
	SII	8.71	5.86	4.65	2.10	0.15
	P for SII linear trend			0.038		
Women						
Education(yr)	≥13	11.84(11.75-11.93)	9.05(8.92-9.17)	9.23(9.17-9.29)	10.74(10.68-10.79)	9.67(9.62-9.71)
	10-12	16.73(16.68-16.79)	15.10(15.05-15.16)	15.91(15.86-15.95)	15.08(15.04-15.12)	13.01(12.98-13.04)
	7-9	22.37(22.31-22.44)	19.26(19.19-19.32)	17.67(17.59-17.74)	20.47(20.38-20.57)	19.36(19.25-19.47)
	≤6	18.75(18.69-18.80)	22.40(22.33-22.48)	19.55(19.44-19.66)	20.86(20.74-20.98)	24.26(24.11-24.42)
	SII	10.78	17.02	13.10	14.39	18.80
	P for SII trend			0.060		
Income	Q1 (highest)	15.39(15.34-15.44)	14.49(14.45-14.54)	13.87(13.83-13.91)	14.13(14.09-14.17)	9.85(9.82-9.88)
	Q2	20.03(19.97-20.08)	17.69(17.64-17.74)	13.72(13.68-13.76)	14.53(14.49-14.57)	13.26(13.22-13.29)
	Q3	17.58(17.53-17.64)	17.44(17.40-17.49)	16.31(16.27-16.36)	17.06(17.01-17.10)	18.44(18.40-18.49)
	Q4 (lowest)	18.00(17.94-18.05)	18.47(18.42-18.52)	17.59(17.54-17.64)	18.15(18.10-18.19)	15.37(15.33-15.41)
	SII	2.21	4.62	5.48	5.82	8.71
	P for SII linear trend			0.057		

Supplementary table 5. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypercholesterolemia by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	7.09(7.06-7.13)	9.66(9.62-9.69)	11.23(11.19-11.26)	12.20(12.17-12.23)
	10-12	8.20(8.18-8.23)	9.52(9.50-9.55)	12.38(12.35-12.41)	13.26(13.23-13.30)
	7-9	4.27(4.24-4.30)	10.26(10.19-10.33)	9.84(9.78-9.90)	16.91(16.77-17.06)
	≤6	7.62(7.56-7.67)	8.92(8.81-9.03)	8.92(8.86-8.98)	12.15(11.95-12.36)
	SII	-1.40	-0.28	-3.02	2.80
	P for SII trend		0.378		
Income	Q1 (highest)	8.03(8.00-8.06)	9.89(9.86-9.93)	13.06(13.02-13.10)	13.63(13.59-13.68)
	Q2	4.83(4.80-4.86)	8.66(8.62-8.69)	8.91(8.87-8.94)	14.67(14.63-14.71)
	Q3	7.64(7.61-7.68)	8.77(8.74-8.81)	12.89(12.86-12.93)	10.93(10.90-10.97)
	Q4 (lowest)	8.92(8.89-8.95)	10.17(10.13-10.20)	12.41(12.37-12.45)	11.46(11.43-11.50)
	SII	2.27	0.34	0.86	-4.08
	P for SII linear trend		0.085		
Women					
Education(yr)	≥13	13.45(13.29-13.60)	13.08(13.01-13.15)	12.24(12.18-12.30)	12.38(12.33-12.43)
	10-12	8.36(8.32-8.39)	9.71(9.68-9.75)	13.72(13.68-13.76)	10.99(10.96-11.02)
	7-9	7.05(6.99-7.10)	10.34(10.26-10.41)	11.15(11.09-11.21)	9.75(9.70-9.80)
	≤6	5.16(5.14-5.18)	11.85(11.77-11.94)	9.82(9.79-9.85)	10.36(10.32-10.40)
	SII	-10.25	-1.89	-3.27	-3.20
	P for SII trend		0.177		
Income	Q1 (highest)	7.95(7.92-7.98)	10.24(10.21-10.28)	12.44(12.40-12.48)	11.81(11.77-11.85)
	Q2	7.38(7.35-7.41)	9.22(9.19-9.26)	12.17(12.14-12.21)	9.80(9.77-9.84)
	Q3	5.55(5.52-5.57)	10.00(9.96-10.03)	11.74(11.71-11.78)	14.21(14.17-14.25)
	Q4 (lowest)	7.64(7.60-7.67)	10.91(10.87-10.94)	13.80(13.76-13.84)	11.65(11.62-11.69)
	SII	-1.08	1.08	1.49	1.58
	P for SII linear trend		0.535		

BMJ Open

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population (Korea National Health and Nutrition Examination Survey, 2001-2014): a cross-sectional study

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-014070.R2
Article Type:	Research
Date Submitted by the Author:	25-Jan-2017
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Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, Health policy, Public health
Keywords:	Health inequality, cardiovascular disease, trend, cardiovascular disease risk factors

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population (Korea National Health and Nutrition Examination Survey, 2001-2014): a cross-sectional study

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Word count: 3499

ABSTRACT

Objectives: To examine trends in socioeconomic inequalities in major cardiovascular disease (CVD) risk factors among the Korean population

Design: Cross-sectional study

Setting: A nationally representative population survey database

Participants: A total of 42,725 Koreans, aged 25-64 years, who participated in the Korean National Health and Nutrition Examination Survey (KNHANES) II (2001) to VI (2013-2014)

Main outcome measures: Trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia)

Results Gender differences were noted in the time trends in socioeconomic inequalities in smoking, obesity, diabetes and hypertension. Among men, low socioeconomic status (SES) was associated with higher prevalence of smoking, but not with obesity, diabetes or hypertension. The magnitudes of socioeconomic inequalities in smoking, obesity and diabetes remained unchanged, and the magnitude of the inequality in hypertension decreased over time. However, among women**,** low SES was associated with higher prevalence of smoking, obesity, diabetes and hypertension. Time trends towards increasing socioeconomic inequalities, measured by income, in smoking, obesity and diabetes were found in women. Unlike the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequality.

Conclusions SES had a stronger impact on major CVD risk factors among Korean women than men. Moreover, socioeconomic inequalities in smoking, obesity and diabetes worsened among Korean women over time. Public policies to prevent smoking, obesity and diabetes in

women with lower SES are needed to address inequalities.

Keywords: trend, health inequality, cardiovascular disease, cardiovascular disease risk factors

Strengths and limitations of the study

- The strength of this study is that a nationally representative sample was used as the study population.
- The limitation of this study is that a period longer than 14 years could not be used for the investigation of socioeconomic inequalities, as data from KNHANES I (1998) were excluded due to a lack of reliability and there was no available nationally representative data before 1998.
- The steady decline of response rates in the KNHANES could result in underestimation of inequalities.

INTRODUCTION

Socioeconomic status (SES) has shown inverse associations with cardiovascular disease (CVD) in most industrialised Western countries, such that disadvantaged groups experience higher risks for CVD.[1-2] A considerable portion of the association between SES and CVD has been attributed to the combined effects of inequalities in health-related behaviours, environmental conditions, social structures and contact with and delivery of healthcare services.[3] As CVD mortality and morbidity contribute sizeable proportions to overall health inequality, attempts to reduce these causes of death are public health concerns.[4] Previous studies have shown that a greater decline in the prevalence of CVD risk factors among higher SES groups widened the gap among SES groups over time in the US.[5-6] However, studies in England and Australia failed to provide strong evidence that socioeconomic inequalities in CVD risk factors had increased in recent decades.[7-8]

Korea, a recently developed country, has experienced rapid socioeconomic growth. The per capita gross national income has increased 2.5-fold over the past 14 years (from $11.000 US in 2001 to $27,000 US in 2014), but the gap in socioeconomic circumstances has widened during this period.[9-10] Thus, it remains unclear whether the increased overall wealth has improved the health status of all segments of the population.

To our knowledge, no previous study has examined time trends in socioeconomic inequalities with regard to major CVD risk factors in Koreans. The purpose of this study was to examine recent national trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia) using national survey data by gender.

METHODS

Study participants

This study was based on data from five consecutive Korean National Health and Nutrition Examination Surveys (KNHANES) conducted from 2001 to 2014. The KNHANES is a national survey that assesses the general health and nutritional status of the Korean population. A detailed description of the survey design and data collection in the KNHANES has been published before.[11] The KNHANES was initiated in 1998 but we excluded the data from KNHANES I (1998) due to a lack of reliability.[12] The response rates were 92.3%, 99.1%, 78.4%, 80.8%, and 78.6% for KNHANES II, III, IV, V, and VI, respectively. In this study, the study population was limited to adults aged 25-64 years to examine trends in socioeconomic inequalities. Considering the applicability of SES (income and education), we excluded survey participants aged younger than 25 years who may not have completed their education or have no job and those older than 64 years who were mostly economically inactive. For the four CVD risk factors (obesity, diabetes, hypertension and hypercholesterolemia), total number of participants in the analysis was 42,725, which included 5,206 participants from the KNHANES II (2001), 4,286 participants from the KNHANES III (2005), 12,407 participants from the KNHANES IV (2007-2009), 12,977 participants from the KNHANES V (2010-2012), and 7,849 participants form the KNHANES VI (2013-2014) (Fig. 1). The total number of participants including in the smoking analysis was 45,522, which is, different from the number included in the analysis of other risk factors because health interview data, instead of health examination data, were used to determine subjects' smoking status. We composed the five data sets for each CVD risk factor individually, excluding the data with missing values for each CVD risk factor.

Health interview and health examination survey

The KNHANES consists of three components: a health interview, a health examination, and a nutrition survey. The health interview survey collects detailed information on SES (e.g. education level, household income), smoking and drinking behaviours, and healthcare utilisation. Prior diagnosis of diabetes and hypertension by a physician and current use of anti-hypertensive and anti-hyperglycaemic agents are included in the questionnaire (for example, for treatment of diabetes, "what is your treatment for diabetes mellitus?", with the following answer categories: insulin, oral hypoglycemic agents or lifestyle modification.) Height to the nearest 0.1 cm was measured using portable stadiometers. Weight to the nearest 0.1 kg was measured using a portable electronic scale. According to the standard protocol, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained nurses using a mercury sphygmomanometer (Baumanometer Desk model; Baum, NY, USA) on the right arm of the subject while sitting after at least 5 min of rest.

Blood sample collection and biochemical analysis

Venous blood samples were obtained from each participant in the morning after fasting for at least 8 h. All samples were processed according to the protocols of KNHANES. After blood collection, an 8 mL serum separating tube for analysing blood lipid level was kept at room temperature for 30 min, and the blood was subsequently centrifuged (3000 rpm, 15 min). A 2 ml sodium fluoride tube for analysing glucose levels was mixed in a roller mixer for 10 min. All blood samples were refrigerated at 2-8°C and then transported to the central laboratory. Within 24 h of blood collection, plasma concentrations of glucose and lipid were assayed

using an Advia 1650 (Siemens, NY, USA) in 2005 and 2007 and using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) since 2008. Since 2005, all laboratory analyses were performed according to the protocol and monitored to ensure the values met acceptable standards of precision and reproducibility in a central laboratory. Because quality control for the biochemical analysis of blood was started in 2005, we analysed the data of serum glucose and total cholesterol that were collected since 2005 in this study.

SES indicators

Education level and income were used as SES indicators. Education level was grouped into four categories: college or higher (≥13 years), high school (10-12 years), middle school (7-9 years), elementary school or less (≤6 years). The measure of income was equivalised gross household income per month, defined as total household income divided by the square root of the number of household members to adjust for the effect of the number of individuals in the household. We divided study subjects into four groups according to quartiles of equivalised household income by gender and age (Q1–Q4; Q1, highest quartile; Q4, lowest quartile).

Definition of CVD risk factors

Smoking, obesity, diabetes, hypertension and hypercholesterolemia were examined because these are major independent risk factors for CVD.[13] Cigarette smoking was defined as a "yes" answer to both of the following questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as a BMI of ≥25 kg/m^2, according to the re-defined criteria of the World Health Organization for obesity

in the Asia-Pacific region.[14] Based on the criteria of the World Health Organization, diabetes was defined as fasting plasma glucose of ≥126 mg/dL, a previous diagnosis of diabetes by a physician, or current use of anti-hyperglycaemic agents or insulin.[15] According to the criteria of the 7th Report of the Joint National Committee, hypertension was defined as an average SBP and/or DBP ≥140/90 mmHg or the use of anti-hypertensive agents.[16] According to the guidelines for cholesterol of the NCEP ATP III, hypercholesterolemia was defined as a plasma total cholesterol of ≥240 mg/dL or current use of cholesterol-lowering agents.[17]

Statistical analysis

The demographic characteristics of the study participants are presented as the means ± standard errors (SE) or age-adjusted prevalence (SE). Comparisons of the characteristics across survey periods were performed using analysis of variance (ANOVA) or χ^2 test, as appropriate, and χ^2 linear trend test was also used. To adjust differences in results from changes in age structure of each survey, age-adjusted prevalence was calculated using a direct standardization method based on 2010 Korea Census.

The relative index of inequality (RII), a measure of effect that permits meaningful comparisons of socioeconomic health inequalities over survey periods was computed. The RII enables direct comparisons between SES variables with regard to the proportions of the population in different categories. To obtain the RII for each indicator of SES, a score between 0 (for the highest SES) and 1 (for the lowest SES) was assigned to each category based on the proportion of subjects above the midpoint in the category. For example, if 10% of the subjects were in the highest educational category, participants in the group were

represented by the range 0-0.1 and given a score of 0.05 (half of 0.1). If 20% of the population were in the next group, participants in the group were given a score of 0.2 (0.1 plus 0.2/2). The RII was obtained by regressing the outcome on each of the SES scores and was directly interpretable for each SES indicator used to compare participants with lowest SES (1) with those with the highest SES (0). In this study, the RII of major CVD risk factors is presented using the odds ratio and 95% confidence interval computed from binary logistic regression analysis adjusted for age. Trends in the RII were examined by estimating the p value for an interaction term of SES indicator and the variables that identified the year of the data in the model. Survey year was entered into the model as a numerical value (e.g., 2001 for KNHANES II). We also calculated a slope index of inequality (SII) for each risk factor in each survey. The SII was measured using the regression coefficient (slope) for the linear relationship between the prevalence of a CVD risk factor in a socioeconomic category in the overall distribution of the SES, and relative rank of that category in the overall distribution of the SES. The regression coefficient can be interpreted as the absolute difference in prevalence across the entire SES distribution. In addition, we investigated gender and SES association in an interaction model to examine whether there was a significant difference between the trends in men and women.

As data from KNHANES were derived from stratified and multi-stage clustered probability sampling methods to represent the entire South Korean population, population weightings were also applied in the analyses. The PROC SURVEY procedure was used to apply stratification, primary sampling units and population weights. Significance levels were set at a two tailed p-value <0.05. All analyses were conducted using the SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

The general characteristics of participants in the KNHANES II (2001) to VI (2013-2014) are shown in Table 1. The mean age of participants increased over time (41.2 ± 0.2 to 43.8 ± 0.2 years and 41.6 ± 0.2 to 44.2 ± 0.2 years for men and women, respectively). The proportion of participants with college or higher education (≥13 years) increased gradually, from 39% to 47% for men and from 24% to 39% for women from 2001 to 2014. There were significant interaction effects between gender and SES on RII except for hypercholesterolemia. The p-values for gender by education interaction were <0.001, <0.001, <0.001, <0.001 and 0.768 for smoking, obesity, diabetes, hypertension and hypercholesterolemia, respectively, while those for the interaction of gender by income were <0.001, <0.001, 0.033, 0.048 and 0.302, respectively. Therefore, we examined the trends in socioeconomic inequalities for major CVD risk factors by gender.

Smoking

Over the past 14 years, the age-adjusted smoking prevalence decreased significantly, from 64% to 47% in men, but it did not change in women (Table 1). Low SES was associated with a high prevalence of smoking in both genders (Table 2). Among Korean men, time trends in socioeconomic inequalities in smoking prevalence by education and income levels were generally stable during 2001-2014. In contrast, a significantly increasing trend in socioeconomic inequalities with regard to smoking prevalence was noted among women (Table 2).

Table 1 General characteristics of the study population (25-64 years) from 2001 to 2014

	KNHANES*					P-value†
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14	
Men						
n	3164	2868	5318	5501	3315	
Age	41.2±0.2	41.1±0.3	42.4±0.2	43.1±0.2	43.8±0.2	<0.001
BMI	23.9±0.1	24.2±0.1	24.3±0.1	24.3±0.1	24.6±0.1	<0.001
Education (yr)						<0.001
≤6	9.4 (0.8)	8.3 (0.6)	9.6 (0.5)	8.3 (0.5)	7.2 (0.6)	
7-9	12.1 (0.7)	10.0 (0.7)	10.5 (0.5)	10.1 (0.5)	8.8 (0.6)	
10-12	39.8 (1.2)	42.4 (1.2)	39.4 (0.9)	38.6 (0.8)	36.9 (1.1)	
≥13	38.7 (1.6)	39.2 (1.4)	40.5 (1.0)	43.0 (0.9)	47.1 (1.2)	
Income‡						0.234
Q1(highest)	22.3 (1.3)	26.7 (1.2)	24.8 (0.8)	26.5 (0.8)	25.0 (1.0)	
Q2	24.0 (1.0)	25.2 (1.0)	24.2 (0.7)	25.6 (0.8)	26.0 (0.9)	
Q3	26.6 (1.0)	23.1 (0.9)	25.4 (0.7)	24.5 (0.7)	24.7 (0.9)	
Q4(lowest)	27.0 (1.4)	25.0 (1.3)	25.7 (1.0)	23.5 (0.8)	24.2 (1.2)	
Prevalence§						
Smoking	64.0	54.8	49.0	49.7	47.1	0.03
Obesity	33.9	38.4	39.7	38.8	41.4	0.038
Diabetes	7.3	9.2	8.9	8.8	9.9	0.076
Hypertension	27.9	26.8	23.3	26.0	25.6	0.404
Hypercholesterolemia	8.6	7.4	9.5	11.7	12.6	0.062
Women						
n	3509	3276	7048	7410	4497	
Age	41.6±0.3	41.6±0.3	42.7±0.2	43.5±0.2	44.2±0.2	<0.001
BMI	23.4±0.1	23.4±0.1	23.2±0.1	23.3±0.1	23.1±0.1	0.018
Education						<0.001
≤6	19.2 (1.1)	17.3 (0.9)	17.2 (0.6)	15.5 (0.6)	12.5 (0.7)	
7-9	14.6 (0.7)	13.2 (0.7)	12.3 (0.5)	11.6 (0.5)	10.2 (0.5)	
10-12	42.2 (1.1)	42.0 (1.3)	40.6 (0.7)	38.9 (0.8)	38.3 (0.9)	
≥13	24.1 (1.4)	27.6 (1.5)	29.9 (0.9)	34.0 (0.9)	39.1 (1.1)	
Income‡						0.133
Q1(highest)	23.1 (1.3)	25.9 (1.1)	24.3 (0.8)	27.6 (0.8)	24.7 (0.9)	
Q2	24.0 (0.9)	25.7 (1.0)	25.3 (0.7)	25.8 (0.7)	25.0 (0.9)	
Q3	26.1 (0.9)	24.2 (0.9)	25.2 (0.7)	24.4 (0.7)	25.1 (0.9)	
Q4(lowest)	26.9 (1.5)	24.2 (1.3)	25.2 (0.9)	22.3 (0.7)	25.2 (1.2)	
Prevalence§						
Smoking	3.7	5.4	6.0	6.9	5.8	0.125
Obesity	30.8	29.7	26.8	28.0	24.4	0.036
Diabetes	5.9	5.3	5.7	5.4	5.4	0.177
Hypertension	17.7	16.9	15.3	16.1	14.2	0.034
Hypercholesterolemia	8.8	7.0	10.1	12.5	11.9	<0.001

Values given are n, prevalence (SE) or mean ± SE

*KNHANES (Korean National Health and Nutrition Examination Survey)
†P-value by ANOVA or χ^2test
‡Quartiles based on equivalised household income
§Age-adjusted prevalence

Table 2 Age-adjusted odds ratios (OR) and 95% confidence interval (CI) and relative indices of inequalities (RII) in smoking by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.75 (1.45-2.12)	1.86 (1.53-2.25)	1.57 (1.37-1.81)	1.47 (1.27-1.71)	1.48 (1.23-1.78)
7-9	1.48 (1.14-1.93)	1.57 (1.13-2.18)	2.16 (1.72-2.71)	1.62 (1.27-2.05)	1.25 (0.92-1.72)
≤6	2.41 (1.72-3.37)	2.22 (1.62-3.05)	1.95 (1.53-2.48)	1.71 (1.32-2.22)	1.77 (1.26-2.49)
RII (95% CI)	2.73 (1.97-3.79)	2.75 (2.00-3.79)	2.74 (2.16-3.48)	2.16 (1.69-2.77)	2.17 (1.57-3.00)
P for trend			0.193		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.23 (0.97-1.55)	1.34 (1.05-1.72)	1.31 (1.11-1.56)	1.09 (0.91-1.30)	1.26 (1.00-1.59)
Q3	1.49 (1.17-1.91)	1.50 (1.21-1.86)	1.56 (1.32-1.85)	1.23 (1.01-1.49)	1.34 (1.07-1.66)
Q4(lowest)	1.74 (1.35-2.24)	1.87 (1.46-2.40)	1.79 (1.51-2.12)	1.50 (1.24-1.81)	1.43 (1.15-1.79)
RII (95% CI)	2.10 (1.53-2.89)	2.22 (1.63-3.02)	2.16 (1.74-2.68)	1.71 (1.34-2.18)	1.57 (1.19-2.08)
P for trend			0.087		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.25 (0.75-2.09)	3.69 (2.07-6.57)	3.95 (2.78-5.62)	2.80 (1.97-4.00)	4.08 (2.67-6.22)
7-9	1.55 (0.76-3.15)	4.04 (1.95-8.34)	6.47 (3.90-10.7)	6.15 (3.65-10.4)	7.75 (4.12-14.6)
≤6	1.98 (1.00-3.90)	4.12 (1.92-8.86)	7.59 (4.42-13.0)	5.52 (3.06-9.9)	9.53 (4.88-18.6)
RII (95% CI)	1.75 (0.87-3.52)	3.41 (1.78-6.55)	8.27 (5.05-13.6)	6.81 (3.86-12.0)	10.29 (5.23-20.2)
P for trend			<0.001		
Income					
Q1(highest)	1	1	1	1	1
Q2	0.53 (0.29-0.95)	1.05 (0.58-1.91)	0.95 (0.64-1.42)	0.98 (0.66-1.46)	1.54 (0.82-2.89)
Q3	0.67 (0.39-1.13)	1.50 (0.90-2.51)	1.46 (1.02-2.09)	1.48 (0.99-2.23)	2.28 (1.29-4.00)
Q4(lowest)	1.53 (0.95-2.47)	2.74 (1.68-4.46)	2.23 (1.57-3.17)	2.53 (1.75-3.65)	3.95 (2.34-6.66)
RII (95% CI)	1.92 (0.88-4.21)	4.45 (2.26-8.76)	3.36 (2.10-5.39)	4.11 (2.46-6.88)	6.27 (3.22-12.20)
P for trend			0.043		

Obesity

We found significant increased trends in the mean BMI (23.9 kg/m^2 in 2001 and 24.6 kg/m^2 in 2014, p <0.001) and the age-adjusted prevalence of obesity (34% for 2001 and 41% for 2014, p=0.038) over time in men (Table 1). In contrast, women showed decreasing trends in mean BMI and the age-adjusted prevalence of obesity (23.4 kg/m^2 in 2001 and 23.1 kg/m^2 in 2014, p=0.018, 31% in 2001 and 24% in 2014, p=0.036; Table 1). Time trends in socioeconomic inequalities in obesity were stable among men; however, a time trend toward increasing inequality in obesity by income was noted in women (1.72, 1.19-2.48 in 2001; 2.69, 2.02-3.59 in 2014, p=0.03, RII, 95% CI, respectively; Table 3).

Diabetes

The age-adjusted prevalence of diabetes did not change significantly over time in either gender (Table 1). Although no significant time trend in socioeconomic inequality for diabetes prevalence was seen in men, significantly increasing inequality in diabetes prevalence was noticed in women, especially by income (0.76, 0.36-1.58 in 2001; 2.56, 1.55-4.22 in 2014, RII, 95% CI, p=0.01, respectively; Table 4).

Hypertension

The age-adjusted prevalence of hypertension did not change significantly over time among men (Table 1). However, the age-adjusted prevalence of hypertension was decreased over time among women. There were also gender differences in the time trend with regard to socioeconomic inequalities in hypertension (Table 5). In men, socioeconomic differences

Table 3 Age-adjusted OR, 95% CI and RII in obesity by SES from 2001 to 2014

	KNHANES				
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	0.96 (0.78-1.20)	0.86 (0.66-1.12)	0.91 (0.79-1.04)	0.89 (0.76-1.04)	1.03 (0.86-1.23)
7-9	0.90 (0.64-1.26)	0.90 (0.57-1.44)	0.80 (0.65-1.00)	0.88 (0.67-1.14)	0.94 (0.68-1.30)
≤6	0.83 (0.55-1.23)	0.43 (0.27-0.67)	0.74 (0.58-0.93)	0.64 (0.48-0.84)	0.80 (0.57-1.11)
RII (95% CI)	0.95 (0.66-1.38)	0.63 (0.40-0.98)	0.74 (0.58-0.94)	0.79 (0.60-1.03)	0.98 (0.72-1.34)
P for trend			0.673		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.15 (0.88-1.51)	0.89 (0.63-1.26)	1,02 (0.86-1.21)	0.89 (0.73-1.08)	0.90 (0.73-1.10)
Q3	0.92 (0.70-1.20)	0.71 (0.52-0.97)	1.02 (0.84-1.23)	0.97 (0.81-1.17)	1.15 (0.91-1.44)
Q4(lowest)	1.11 (0.83-1.47)	0.76 (0.55-1.06)	0.96 (0.80-1.15)	0.74 (0.61-0.90)	0.85 (0.69-1.05)
RII (95% CI)	1.02 (0.71-1.45)	0.66 (0.43-1.02)	0.95 (0.75-1.20)	0.72 (0.57-0.92)	0.91 (0.70-1.20)
P for trend			0.778		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	2.64 (1.93-3.60)	1.99 (1.43-2.77)	1.74 (1.46-2.08)	1.90 (1.59-2.28)	1.76 (1.43-2.18)
7-9	5.53 (3.83-7.98)	2.84 (1.86-4.34)	2.49 (1.98-3.12)	2.45 (1.92-3.12)	2.92 (2.16-3.96)
≤6	3.79 (2.52-5.72)	3.42 (2.28-5.15)	3.55 (2.81-4.50)	2.65 (2.09-3.37)	3.99 (2.92-5.45)
RII (95% CI)	3.19 (2.23-4.57)	3.45 (2.17-5.47)	3.57 (2.83-4.51)	2.93 (2.29-3.73)	4.01 (2.94-5.49)
P for trend			0.617		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.17 (0.90-1.51)	1.50 (1.06-2.11)	1.05 (0.87-1.26)	1.32 (1.07-1.63)	1.65 (1.29-2.10)
Q3	1.30 (0.97-1.73)	1.43 (1.03-1.98)	1.48 (1.24-1.77)	1.51 (1.25-1.83)	1.97 (1.58-2.47)
Q4(lowest)	1.53 (1.15-2.03)	1.63 (1.16-2.29)	1.61 (1.34-1.93)	1.88 (1.54-2.29)	2.21 (1.74-2.81)
RII (95% CI)	1.72 (1.19-2.48)	1.73 (1.15-2.61)	2.03 (1.61-2.56)	2.21 (1.73-2.83)	2.69 (2.02-3.59)
P for trend			0.032		

Table 4 Age-adjusted OR, 95% CI and RII in diabetes by SES from 2005 to 2014

	KNHAENS			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education (yr)				
≥13	1	1	1	1
10-12	1.21 (0.72-2.03)	0.98 (0.74-1.28)	1.39 (1.05-1.85)	1.14 (0.82-1.57)
7-9	1.20 (0.64-2.25)	1.05 (0.73-1.52)	1.41 (0.96-2.06)	1.13 (0.71-1.81)
≤6	1.42 (0.77-2.59)	0.92 (0.64-1.32)	1.30 (0.88-1.90)	1.06 (0.65-1.73)
RII (95% CI)	1.41 (0.72-2.77)	0.91 (0.59-1.40)	1.38 (0.91-2.09)	1.09 (0.64-1.85)
P for trend		0.838		
Income				
Q1(highest)	1	1	1	1
Q2	0.53 (0.30-0.93)	1.12 (0.81-1.56)	0.76 (0.54-1.07)	0.86 (0.58-1.30)
Q3	0.84 (0.49-1.43)	0.96 (0.69-1.32)	0.90 (0.64-1.27)	1.06 (0.73-1.55)
Q4(lowest)	0.93 (0.57-1.53)	1.48 (1.09-2.01)	1.06 (0.77-1.46)	1.34 (0.92-1.95)
RII (95% CI)	1.08 (0.53-2.18)	1.53 (1.02-2.30)	1.17 (0.76-1.79)	1.55 (0.95-2.56)
P for trend		0.557		
Women				
Education (yr)				
≥13	1	1	1	1
10-12	2.69 (1.11-6.53)	2.04 (1.28-3.23)	2.10 (1.30-3.40)	1.38 (0.89-2.12)
7-9	3.30 (1.00-10.9)	1.76 (1.02-3.05)	2.23 (1.26-3.96)	1.76 (1.02-3.02)
≤6	4.33 (1.42-13.3)	3.29 (1.93-5.59)	2.85 (1.62-5.02)	1.68 (0.99-2.87)
RII (95% CI)	3.69 (0.99-13.8)	3.33 (1.99-5.57)	2.61 (1.57-4.35)	1.92 (1.14-3.23)
P for trend		0.254		
Income				
Q1(highest)	1	1	1	1
Q2	0.86 (0.46-1.59)	1.06 (0.70-1.59)	1.84 (1.21-2.79)	1.13 (0.72-1.78)
Q3	1.10 (0.62-1.98)	1.75 (1.23-2.50)	2.36 (1.55-3.57)	1.23 (0.79-1.91)
Q4(lowest)	0.71 (0.39-1.31)	1.99 (1.39-2.87)	2.56 (1.72-3.82)	2.04 (1.38-3.01)
RII (95% CI)	0.76 (0.36-1.58)	2.80 (1.77-4.42)	2.90 (1.89-4.47)	2.56 (1.55-4.22)
P for trend		0.015		

Table 5 Age-adjusted OR, 95% CI and RII of hypertension by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.43 (1.08-1.89)	1.03 (0.75-1.40)	1.03 (0.86-1.25)	1.15 (0.97-1.38)	0.97 (0.78-1.22)
7-9	1.22 (0.84-1.78)	1.50 (0.96-2.36)	0.98 (0.77-1.24)	1.12 (0.87-1.44)	0.93 (0.69-1.24)
≤6	1.17 (0.77-1.79)	1.31 (0.85-2.02)	1.08 (0.84-1.40)	1.15 (0.89-1.49)	1.01 (0.70-1.47)
RII (95% CI)	1.34 (0.88-2.03)	1.41 (0.90-2.20)	1.08 (0.82-1.42)	1.16 (0.88-1.52)	0.93 (0.66-1.32)
P for trend			0.133		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.21 (0.86-1.69)	0.87 (0.59-1.29)	1.09 (0.88-1.35)	1.13 (0.91-1.42)	1.28 (0.95-1.71)
Q3	1.10 (0.76-1.59)	0.95 (0.70-1.29)	1.11 (0.89-1.39)	1.11 (0.89-1.37)	1.09 (0.83-1.43)
Q4(lowest)	1.58 (1.14-2.19)	1.23 (0.90-1.69)	1.23 (0.99-1.54)	1.11 (0.89-1.38)	1.05 (0.80-1.39)
RII (95% CI)	1.64 (1.09-2.49)	1.37 (0.91-2.06)	1.30 (0.99-1.71)	1.11 (0.85-1.46)	0.99 (0.71-1.39)
P for trend			0.042		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.55 (0.93-2.61)	1.91 (1.14-3.18)	2.21 (1.62-3.02)	1.69 (1.32-2.17)	1.80 (1.30-2.47)
7-9	2.64 (1.47-4.76)	2.90 (1.60-5.25)	2.50 (1.76-3.55)	2.15 (1.58-2.92)	2.59 (1.78-3.77)
≤6	1.79 (0.99-3.24)	3.18 (1.68-5.99)	2.69 (1.91-3.80)	2.45 (1.83-3.30)	3.06 (2.10-4.46)
RII (95% CI)	1.48 (0.89-2.46)	2.11 (1.21-3.69)	1.93 (1.38-2.70)	2.15 (1.56-2.97)	2.91 (1.98-4.29)
P for trend			0.060		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.48 (1.06-2.07)	1.37 (0.92-2.05)	0.99 (0.80-1.23)	1.04 (0.82-1.33)	1.44 (1.04-1.98)
Q3	1.15 (0.78-1.69)	1.33 (0.92-1.93)	1.25 (1.00-1.55)	1.29 (1.01-1.65)	2.33 (1.74-3.13)
Q4(lowest)	1.29 (0.85-1.94)	1.50 (0.99-2.28)	1.39 (1.11-1.76)	1.41 (1.11-1.78)	1.73 (1.28-2.36)
RII (95% CI)	1.22 (0.73-2.04)	1.62 (0.97-2.71)	1.63 (1.20-2.22)	1.65 (1.23-2.21)	2.32 (1.63-3.30)
P for trend			0.056		

decreased with income over the past 14 years (1.64, 1.09-2.49 in 2001; 0.99, 0.71-1.39 in 2014, RII, 95% CI, p=0.04), whereas inequalities were increased with marginal significance among women during the same period (1.48, 0.89-2.46 in 2001; 2.91, 1.98-4.29 in 2014, RII, 95% CI, p=0.06, by education; 1.22, 0.73-2.04 in 2001; 2.32, 1.63-3.30 in 2014, RII, 95% CI, p=0.056, by income, respectively; Table 5).

Hypercholesterolemia

The age-adjusted prevalence of hypercholesterolemia among men increased with marginal statistical significance. The age-adjusted prevalence of hypercholesterolemia among women increased over time (Table 1). There was no significant association between SES and hypercholesterolemia in either gender (Table 6).

DISCUSSION

The results of this study reflect gender differences not only in the relationships between major CVD risk factors and SES, but also in the linear time trends in socioeconomic inequalities in major CVD risk factors among Koreans. Among men, no major CVD risk factor, except for smoking showed significant associations with SES. Indeed, socioeconomic inequalities for major CVD risk factors were stable over time and inequality for hypertension decreased over the past 14 years. However, women with a lower SES had higher risks of smoking, obesity, diabetes and hypertension than did those with a higher SES. Increasing trends in socioeconomic inequalities in smoking, obesity and diabetes, especially measured by income, were noted in Korean women. In contrast to the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequalities in either gender.

Table 6 Age-adjusted OR, 95% CI and RII of hypercholesterolemia by SES from 2005 to 2014

	KNHANES			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education(yr)				
≥13	1	1	1	1
10-12	1.12 (0.68-1.82)	1.06 (0.82-1.36)	1.12 (0.88-1.43)	1.08 (0.81-1.42)
7-9	0.72 (0.29-1.79)	1.16 (0.80-1.69)	1.05 (0.77-1.44)	0.91 (0.54-1.52)
≤6	1.02 (0.55-1.91)	0.83 (0.57-1.23)	1.09 (0.74-1.60)	0.92 (0.58-1.45)
RII (95% CI)	0.89 (0.42-1.87)	1.00 (0.67-1.51)	1.14 (0.79-1.65)	0.93 (0.57-1.53)
P for trend			0.906	
Income				
Q1 (highest)	1	1	1	1
Q2	0.54 (0.29-1.01)	0.86 (0.63-1.17)	0.64 (0.48-0.85)	1.15 (0.81-1.64)
Q3	0.87 (0.46-1.66)	0.88 (0.66-1.18)	0.97 (0.74-1.28)	0.81 (0.56-1.18)
Q4 (lowest)	0.98 (0.54-1.78)	1.02 (0.77-1.35)	0.93 (0.71-1.21)	0.85 (0.59-1.23)
RII (95% CI)	1.14 (0.48-2.72)	1.02 (0.71-1.48)	1.08 (0.76-1.54)	0.72 (0.45-1.14)
P for trend			0.301	
Women				
Education (yr)				
≥13	1	1	1	1
10-12	0.95 (0.47-0.91)	0.76 (0.56-1.02)	1.31 (0.99-1.73)	0.84 (0.62-1.15)
7-9	0.66 (0.30-1.44)	0.74 (0.52-1.05)	1.12 (0.80-1.56)	0.95 (0.63-1.43)
≤6	0.69 (0.31-1.57)	0.83 (0.58-1.19)	1.19 (0.84-1.67)	0.95 (0.63-1.43)
RII (95% CI)	0.64 (0.27-1.53)	0.85 (0.58-1.24)	1.08 (0.75-1.54)	0.85 (0.55-1.33)
P for trend			0.499	
Income				
Q1 (highest)	1	1	1	1
Q2	0.82 (0.47-1.44)	0.88 (0.67-1.17)	0.98 (0.77-1.24)	0.79 (0.58-1.09)
Q3	0.65 (0.36-1.17)	0.97 (0.73-1.28)	0.93 (0.72-1.19)	1.29 (0.95-1.75)
Q4 (lowest)	0.96 (0.59-1.54)	1.08 (0.82-1.42)	1.12 (0.88-1.42)	1.02 (0.76-1.37)
RII (95% CI)	0.87 (0.44-1.70)	1.13 (0.79-1.61)	1.14 (0.84-1.54)	1.24 (0.85-1.81)
P for trend			0.397	

Socioeconomic inequalities in CVD risk factors and disease-related mortality are well known in industrialised Western countries and are now being found in many developing countries as well.[1-2, 18-19] However, there has been relatively little research examining time trends in socioeconomic inequalities in these CVD risk factors.[6-8] To our knowledge, this is the first report on trends in socioeconomic inequalities in major CVD risk factors in an Asian nation.

In this study, distinct gender differences in time trend for smoking prevalence were found between Korean men and women, which is consistent with trends in other Asian countries, such as China and Taiwan.[20−21] Over the past 14 years, the smoking prevalence in men decreased, but that among women did not change significantly. Consistent with previous reports, our study showed that Koreans with a lower SES had higher smoking prevalence than those with a higher SES in both gender.[22-23] However, our study further showed gender differences in the time trend of smoking inequality. Based on the RII trend, the trend in inequality was stable among men, but the socioeconomic gap among women widened. There has been significant progress with anti-smoking policies in Korea in recent years. In 1995, the Health Promotion Act was enacted and restricted smoking in public buildings and places. In 2004, a significant increase in taxation of tobacco products began.[24] We suspected that these policies may have been effective among men in all socioeconomic groups, but they were ineffective for women with lower SES.

Over the past 14 years, the prevalence of obesity has increased in men, but it has decreased in women. Among men, SES was not associated with the prevalence of obesity; however, lower SES was associated with a higher prevalence of obesity in women, reflecting gender differences in attitudes towards body image in Korea.[25] Men and women could have different attitudes toward body weight status and may use different methods for controlling body weight. As societies develop, women tend to acquire a more negative attitude towards

obesity than do men. Additionally, public attitudes are more strongly negative towards obese women than towards obese men. Thus, women are more likely to use their resources to pursue a thinner body than are men, and women tend to shift their diet and activity patterns to a healthier lifestyle more rapidly than do men.[26-27]

The prevalence of diabetes did not change in either gender during the study period. Our study found gender differences in association between SES and the prevalence of diabetes, which is consistent with previous studies that reported the influence of SES on the risk of diabetes was more pronounced in women than in men.[19, 28-30] To our knowledge, there is no previous study investigating time trends in socioeconomic inequalities for diabetes in Koreans. The inequality in diabetes among women, measured by income, increased during the past 14 years, which is consistent with previous studies in other countries.[31-32] Although the reasons for this gender difference remain unclear, several plausible explanations that relate low SES to an increased risk of diabetes in women can be proposed. Socioeconomic inequalities may cause differing lifestyle behaviours, such as alcohol intake and physical activity. Women with a lower SES have higher risk of harmful alcohol consumption, smoking and lack of physical activity.[3, 33-34] It may also be related to less social support and poorer access to healthcare services, leading to lower levels of the detection and treatment of diabetes and its associated risk factors.[35] Finally, women with a lower SES may have poor eating habits, such as a less intake of fruits and vegetables.[36]

During the study period, the prevalence of hypertension did not change among men, but decreased among women. The pattern of associations between SES and risk of hypertension differed by gender, which is consistent with a previous study.[37] The influence of low SES on hypertension was more prominent and socioeconomic inequalities widened with marginal statistical significance in women during study period. In contrast, the socioeconomic

inequality among men was decreased, although the reason for this alleviation of inequality was not clear. One possible explanation is that the marginally significant diminished inequality with respect to smoking in men during the study period may mitigate the inequality.

Trends in socioeconomic inequalities in obesity and diabetes among women increased by income level, but they were not significant when measured by education. Rapid social change has affected the meaning of education level; for example, the proportion of women who had an education level of college or above was 24% in KNHANES II (2001). However, it was ~40% in KNHANES VI (2013-2014). Thus, caution is needed in comparing education groups across time, especially in rapidly changing societies. Additionally, it may be better to divide education levels into equal parts to investigate health inequalities.[26, 38]

Investigating the trend of RIIs was a commonly used method to assess relative measure of health inequality, but in some cases, absolute and relative measure may diverge with respect to magnitude or the direction of change in health inequality.[39] Therefore, we also examined the SIIs as absolute measures of inequalities for five major CVD risk factors, and found no difference in trends between relative and absolute inequalities (Supplementary Table 1-5).

Two strengths of our study are that study subjects were a nationally representative sample and that the time trends of the relationship between SES and five major CVD risk factors were examined using two SES measures (education level, household income). However, several limitations also be noted. First, the study was cross-sectional in nature; thus, it was difficult to determine causal relationships between SES and CVD risk factors. Second, the KNHANES is a self-report survey and therefore prone to measurement error and recall bias as well as heterogeneity in self-reported health. Third, the steady decline in response rates in the KNHANES should not be overlooked, which could result in underestimating

inequalities.[40] Moreover, item responses were possibly associated with SES because there were significantly different SES distributions between item responders and non-responders for each of risk factor (Supplementary Tables 6-10), which may have resulted in underestimation. Fourth, the generalisability of our results to whole Korean population is limited since our study included only individuals aged 25-64 years, and institutionalised older adults were excluded.[11] Finally, we could not examine longer-term trends in socioeconomic inequalities in CVD risk factors before 2001, because, following the authors' judgement, the KNHANES I (1998) survey data were excluded due to lack of reliability.

CONCLUSIONS

This study found that relationships between SES and major CVD risk factors (smoking, obesity, diabetes, hypertension) were more prominent in Korean women than men. Health inequalities, especially measured by income, for smoking, obesity and diabetes increased among Korean women over the past 14 years. Public policies should be implemented to prevent risk factors for CVD among Korean women with a lower SES.

Contributors YJK, SGK, JL and JSL developed the research questions and contributed to the development of the conceptual framework, and the interpretations of the results. YJK contributed to writing and submitting the manuscript. JSL performed the main analyses and critical revisions to the manuscript. JP provided theoretical support and DSC, DMK, KL and HYK assisted with writing the manuscript.

Funding No funding

Competing interests None declared.

Ethical approval All procedures and protocols of the study were approved by the Institutional Review Board of the Korea Center for Disease Control and Prevention (KCDC) since 2007. Written informed consent regarding the survey and blood analysis has been obtained from all participants since 2001.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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Figure legends

Fig 1. Study enrollment. The enrolled study population was from the Korean National Health and Nutrition Examination Surveys (KNHANES) 2001-2014

*Smoking: data from the health interviews were analysed; total number of participants is 45,522.

†Diabetes and hypercholesterolemia: data from the of KNHANES III (2005) to VI (2014) were analysed; total number of participants is 37,519.

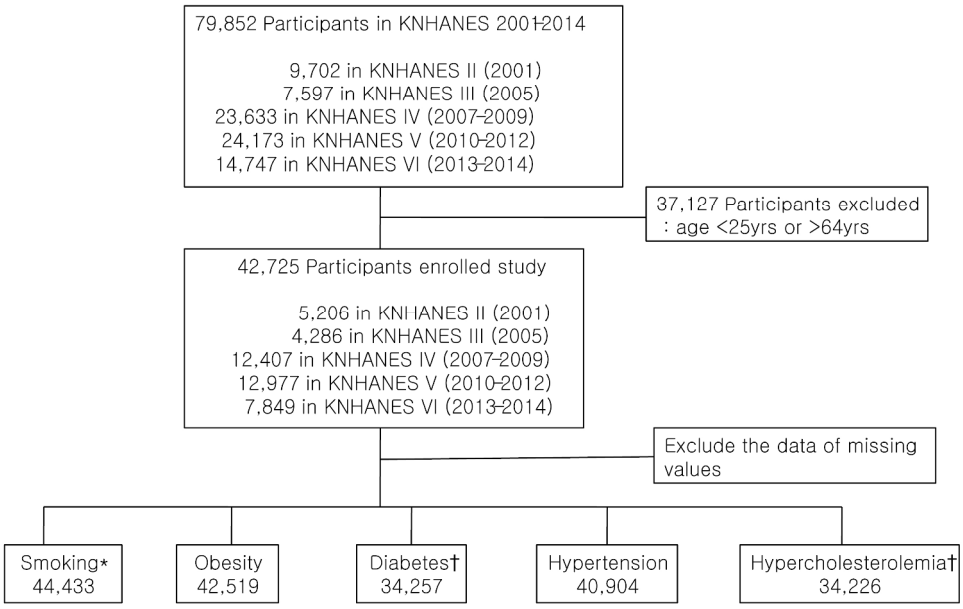

Figure 1

Fig 1. Study enrollment. The enrolled study population was from the Korean National Health and Nutrition Examination Surveys (KNHANES) 2001-2014
The total number of participan
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STROBE 2007 (v4)Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-10
Bias	9	Describe any efforts to address potential sources of bias	*6-8*
Study size	10	Explain how the study size was arrived at	-
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-17
		(*b*) Report category boundaries when continuous variables were categorized	11-20
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	23
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10, 11, 23
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Supplementary table 1. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of smoking by SES from 2001 to 2014

		KNHAENS II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	56.6(56.6-56.7)	46.6(46.5-46.7)	42.0(41.9-42.1)	42.6(42.6-42.7)	41.9(41.9-42.0)
	10-12	68.6(68.5-68.7)	59.2(59.2-59.3)	51.7(51.7-51.8)	53.6(53.5-53.6)	52.6(52.5-52.6)
	7-9	67.4(67.3-67.6)	58.2(58.0-58.5)	63.6(63.4-63.8)	63.0(62.7-63.2)	44.9(44.7-45.1)
	≤6	62.6(62.3-62.9)	51.2(50.9-51.6)	70.0(69.6-70.4)	45.8(45.6-46.1)	64.4(63.9-64.9)
	SII	9.83	8.98	36.53	13.72	20.49
	P for SII trend			0.454		
Income	Q1 (highest)	57.2(57.1-57.2)	47.1(47.0-47.1)	41.2(41.1-41.2)	45.3(45.2-45.4)	42.1(42.0-42.1)
	Q2	62.0(61.9-62.1)	54.0(53.9-54.0)	47.9(47.8-48.0)	47.1(47.0-47.1)	47.4(47.4-47.5)
	Q3	67.4(67.3-67.5)	56.3(56.2-56.3)	52.0(52.0-52.1)	50.3(50.2-50.3)	48.6(48.5-48.7)
	Q4 (lowest)	70.5(70.4-70.6)	62.1(62.1-62.2)	55.5(55.4-55.6)	55.1(55.0-55.1)	50.1(50.0-50.1)
	SII	17.96	19.08	18.92	12.99	9.98
	P for SII linear trend			0.105		
Women						
Education(yr)	≥13	2.9(2.9-3.0)	2.5(2.4-2.5)	2.8(2.8-2.8)	4.3(4.3-4.3)	2.6(2.6-2.6)
	10-12	2.9(2.8-2.9)	6.5(6.5-6.6)	7.5(7.5-7.5)	8.8(8.8-8.9)	8.2(8.2-8.3)
	7-9	3.4(3.4-3.5)	9.2(9.0-9.3)	13.2(13.1-13.3)	26.9(26.7-27.1)	19.4(19.2-19.5)
	≤6	2.6(2.6-2.6)	5.3(5.3-5.4)	15.2(15.0-15.4)	13.1(12.9-13.3)	15.1(14.9-15.3)
	SII	-0.01	5.27	16.69	20.27	20.55
	P for SII trend			0.009		
Income	Q1 (highest)	3.5(3.5-3.5)	3.5(3.5-3.5)	4.2(4.2-4.3)	4.7(4.7-4.7)	2.8(2.8-2.8)
	Q2	2.4(2.3-2.4)	3.9(3.9-4.0)	4.1(4.1-4.1)	4.6(4.5-4.6)	4.4(4.4-4.4)
	Q3	2.8(2.8-2.8)	5.2(5.2-5.2)	6.1(6.0-6.1)	6.8(6.8-6.8)	6.1(6.1-6.2)
	Q4 (lowest)	6.6(6.6-6.7)	9.0(9.0-9.1)	9.0(9.0-9.0)	10.9(10.8-10.9)	10.1(10.0-10.1)
	SII	3.82	7.22	6.48	8.39	9.38
	P for SII linear trend			0.047		

Supplementary table 2. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of obesity by SES from 2001 to 2014

		KNHAES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	36.4(36.3-36.5)	40.0(39.9-40.1)	41.8(41.7-41.8)	40.8(40.8-40.9)	41.4(41.3-41.4)
	10-12	33.1(33.0-33.1)	37.9(37.9-38.0)	39.9(39.8-39.9)	38.8(38.8-38.9)	42.1(42.0-42.1)
	7-9	33.2(33.1-33.3)	45.1(44.9-45.3)	41.3(41.1-41.5)	40.3(40.2-40.5)	32.9(32.8-33.1)
	≤6	28.6(28.4-28.7)	17.2(17.1-17.2)	41.2(41.1-41.5)	29.0(28.7-29.2)	47.6(47.2-48.0)
	SII	-8.22	-16.56	-0.50	-10.54	0.08
	P for SII trend			0.542		
Income	Q1 (highest)	33.9(33.8-34.0)	42.3(42.8-42.9)	40.0(40.0-40.1)	41.7(41.6-41.8)	42.2(42.2-42.3)
	Q2	35.4(35.4-35.5)	40.0(40.0-40.1)	40.5(40.4-40.6)	38.9(38.8-39.0)	39.4(39.3-39.5)
	Q3	32.0(31.9-32.1)	34.2(34.1-34.2)	40.2(40.2-40.3)	40.9(40.8-40.9)	45.6(45.5-45.6)
	Q4 (lowest)	34.3(34.3-34.4)	35.4(35.4-35.5)	39.0(38.9-39.1)	34.5(34.4-34.5)	38.5(38.4-38.5)
	SII	-0.88	-11.40	-1.36	-7.97	-2.05
	P for SII linear trend			0.940		
Women						
Education(yr)	≥13	18.0(17.9-18.1)	19.1(18.9-19.2)	16.7(16.6-16.8)	18.9(18.9-19.0)	16.1(16.0-16.1)
	10-12	30.0(29.9-30.1)	28.8(28.7-28.9)	24.8(24.7-24.8)	29.9(29.9-30.0)	24.3(24.3-24.4)
	7-9	49.8(49.7-50.0)	35.2(35.1-35.3)	31.4(31.3-31.5)	37.0(36.8-37.1)	32.2(32.1-32.4)
	≤6	38.0(37.8-38.2)	34.5(34.4-34.6)	42.9(42.7-43.2)	35.1(34.9-35.3)	50.8(50.5-51.2)
	SII	32.50	21.32	31.76	23.51	40.66
	P for SII trend			0.487		
Income	Q1 (highest)	27.2(27.1-27.3)	23.8(23.7-23.8)	22.5(22.5-22.6)	21.6(21.6-21.7)	16.2(16.1-16.2)
	Q2	30.0(29.9-30.1)	31.5(31.5-31.6)	23.5(23.5-23.6)	26.6(26.5-26.6)	24.0(24.0-24.1)
	Q3	31.3(31.2-31.4)	30.9(30.8-31.0)	29.8(29.7-29.9)	29.2(29.1-29.3)	27.6(27.6-27.7)
	Q4 (lowest)	35.0(34.9-35.0)	33.1(33.0-33.1)	31.7(31.6-31.7)	33.7(33.7-33.8)	29.9(29.8-29.9)
	SII	9.76	10.78	13.43	15.53	17.86
	P for SII linear trend			0.023		

Supplementary table 3. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of diabetes by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	8.1(8.1-8.1)	8.3(8.2-8.3)	7.3(7.3-7.3)	8.9(8.9-8.9)
	10-12	9.4(9.4-9.5)	8.9(8.9-8.9)	9.5(9.5-9.5)	10.3(10.3-10.4)
	7-9	11.3(11.2-11.4)	10.1(10.0-10.2)	9.1(9.0-9.1)	14.2(14.1-14.3)
	≤6	10.2(10.2-10.3)	7.6(7.6-7.7)	11.1(10.9-11.2)	9.4(9.4-9.5)
	SII	3.56	0.41	4.13	3.66
	P for SII trend		0.602		
Income	Q1 (highest)	10.4(10.3-10.4)	7.9(7.9-8.0)	9.3 (9.2-9.3)	9.5(9.5-9.6)
	Q2	6.6(6.6-6.6)	8.6(8.6-8.6)	7.3(7.3-7.3)	8.1(8.1-8.2)
	Q3	9.0(9.0-9.0)	7.8(7.8-7.9)	8.6(8.6-8.7)	9.8(9.8-9.8)
	Q4 (lowest)	10.4(10.3-10.4)	11.4(11.3-11.4)	9.8(9.7-9.8)	12.1(12.1-12.2)
	SII	1.05	3.75	1.16	3.83
	P for SII linear trend		0.576		
Women					
Education(yr)	≥13	0.6(0.6-0.6)	2.8(2.8-2.8)	3.8(3.8-3.8)	3.9(3.8-3.9)
	10-12	5.8(5.7-5.8)	5.2(5.1-5.2)	5.5(5.5-5.5)	5.6(5.6-5.7)
	7-9	7.7(7.6-7.7)	5.3(5.3-5.4)	5.0(5.0-5.1)	7.5(7.4-7.5)
	≤6	7.2(7.1-7.2)	9.2(9.1-9.2)	8.1(8.1-8.2)	7.3(7.3-7.4)
	SII	8.92	7.00	4.55	5.06
	P for SII trend		0.048		
Income	Q1 (highest)	6.1(6.1-6.1)	3.9(3.9-4.0)	2.9(2.8-2.9)	4.3(4.3-4.3)
	Q2	5.1(5.1-5.1)	4.2(4.1-4.2)	4.9(4.9-5.0)	4.6(4.6-4.6)
	Q3	6.4(6.4-6.4)	6.7(6.7-6.7)	6.4(6.3-6.4)	5.1(5.0-5.1)
	Q4 (lowest)	4.4(4.1-4.4)	7.5(7.5-7.5)	6.9(6.8-6.9)	7.9(7.9-7.9)
	SII	-1.51	5.26	5.31	4.45
	P for SII linear trend		0.016		

Supplementary table 4. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypertension by SES from 2001 to 2014

		KNHANES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	24.9(24.8-24.9)	24.7(24.7-24.8)	22.6(22.6-22.7)	24.7(24.6-24.7)	25.3(25.2-25.3)
	10-12	30.6(30.5-30.7)	25.9(25.8-25.9)	23.5(23.5-23.6)	27.1(27.1-27.2)	25.2(25.2-25.3)
	7-9	28.3(28.2-28.4)	27.1(27.0-27.1)	21.9(21.9-22.0)	24.9(24.8-25.0)	23.7(23.5-23.8)
	≤6	28.2(28.0-28.3)	25.0(25.0-25.1)	24.7(24.6-24.9)	29.1(28.9-29.3)	28.5(28.2-28.7)
	SII	3.96	1.52	1.37	3.75	1.79
	P for SII trend			0.888		
Income	Q1 (highest)	24.3(24.2-24.3)	26.3(26.3-26.4)	21.7(21.6-21.7)	24.4(24.4-24.5)	23.6(23.5-23.6)
	Q2	27.8(27.8-27.9)	24.9(24.8-24.9)	23.1(23.0-23.1)	27.0(27.0-27.1)	28.4(28.4-28.5)
	Q3	26.6(26.5-26.6)	26.0(25.9-26.1)	23.5(23.4-23.5)	26.5(26.4-26.5)	25.3(25.3-25.4)
	Q4 (lowest)	32.1(32.1-32.2)	30.6(30.6-30.7)	25.4(25.3-25.4)	26.4(26.3-26.4)	24.8(24.7-24.8)
	SII	8.71	5.86	4.65	2.10	0.15
	P for SII linear trend			0.038		
Women						
Education(yr)	≥13	11.8(11.811.9)	9.1(8.9-9.2)	9.2(9.2-9.3)	10.7(10.7-10.8)	9.7(9.6-9.71)
	10-12	16.7(16.7-16.8	15.1(15.1-15.2)	15.9(15.9-16.0)	15.1(15.0-15.1)	13.0(13.0-13.0)
	7-9	22.4(22.3-22.4)	19.3(19.2-19.3)	17.7(17.6-17.7)	20.5(20.4-20.6)	19.4(19.3-19.5)
	≤6	18.8(18.7-18.8)	22.4(22.3-22.5)	19.6(19.4-19.7)	20.9(20.7-21.0)	24.3(24.1-24.4)
	SII	10.78	17.02	13.10	14.39	18.80
	P for SII trend			0.060		
Income	Q1 (highest)	15.4(15.3-15.4)	14.5(14.5-14.5)	13.9(13.8-13.9)	14.1(14.1-14.2)	9.9(9.8-9.9)
	Q2	20.0(20.0-20.1)	17.7(17.6-17.7)	13.7(13.7-13.8)	14.5(14.5-14.6)	13.3(13.2-13.3)
	Q3	17.6(17.5-17.6)	17.4(17.4-17.5)	16.3(16.3-16.4)	17.1(17.0-17.1)	18.4(18.4-18.5)
	Q4 (lowest)	18.0(17.9-18.1)	18.5(18.4-18.5)	17.6(17.5-17.6)	18.2(18.1-18.2)	15.4(15.3-15.4)
	SII	2.21	4.62	5.48	5.82	8.71
	P for SII linear trend			0.057		

Supplementary table 5. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypercholesterolemia by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	7.1(7.1-7.1)	9.7(9.6-9.7)	11.2(11.2-11.3)	12.0(12.0-12.2)
	10-12	8.2(8.2-8.2)	9.5(9.5-9.6)	12.4(12.4-12.4)	13.3(13.2-13.3)
	7-9	4.3(4.2-4.3)	10.3(10.2-10.3)	9.8(9.8-9.9)	16.9(16.8-17.1)
	≤6	7.6(7.6-7.7)	8.9(8.8-9.0)	8.9(8.9-9.0)	12.2(12.0-12.4)
	SII	-1.40	-0.28	-3.02	2.80
	P for SII trend		0.378		
Income	Q1 (highest)	8.0(8.0-8.1)	9.9(9.9-9.9)	13.1(13.0-13.1)	13.6(13.6-13.7)
	Q2	4.8(4.8-4.9)	8.7(8.6-8.7)	8.9(8.9-8.9)	14.7(14.6-14.7)
	Q3	7.6(7.6-7.7)	8.8(8.7-8.8)	12.9(12.9-12.9)	10.9(10.9-11.0)
	Q4 (lowest)	8.9(8.9-9.0)	10.2(10.1-10.2)	12.4(12.4-12.5)	11.5(11.4-11.5)
	SII	2.27	0.34	0.86	-4.08
	P for SII linear trend		0.085		
Women					
Education(yr)	≥13	13.5(13.3-13.6)	13.1(13.0-13.2)	12.2(12.2-12.3)	12.4(12.3-12.4)
	10-12	8.4(8.3-8.4)	9.7(9.7-9.8)	13.7(13.7-13.8)	11.0(11.0-11.0)
	7-9	7.1(7.0-7.1)	10.3(10.3-10.4)	11.2(11.1-11.2)	9.8(9.7-9.8)
	≤6	5.2(5.1-5.2)	11.9(11.8-11.9)	9.8(9.8-9.9)	10.4(10.3-10.4)
	SII	-10.25	-1.89	-3.27	-3.20
	P for SII trend		0.177		
Income	Q1 (highest)	8.0(7.9-8.0)	10.2(10.2-10.3)	12.4(12.4-12.5)	11.8(11.8-11.9)
	Q2	7.4(7.4-7.4)	9.2(9.2-9.3)	12.2(12.1-12.2)	9.8(9.8-9.8)
	Q3	5.6(5.5-5.6)	10.0(10.0-10.0)	11.7(11.7-11.8)	14.2(14.2-14.3)
	Q4 (lowest)	7.6(7.6-7.7)	10.9(10.9-10.9)	13.8(13.8-13.8)	11.7(11.6-11.7)
	SII	-1.08	1.08	1.49	1.58
	P for SII linear trend		0.535		

Supplementary table 6. Comparing difference of SES distribution between responder and non-responder (smoking)

		Response (n=44433, 98%)		Non-response (n=1089, 2%)	
Education(yr)	≥13	15438	(36%)	36	(27.3%)
	10-12	16815	(38.1%)	49	(37.1%)
	7-9	5272	(12.0%)	19	(14.4%)
	≤6	6583	(14.9%)	28	(21.2%)
p-value*			0.093		
Income	Q1 (highest)	11112	(25.5%)	198	(19.5%)
	Q2	11032	(25.3%)	235	(23.1%)
	Q3	10915	(25.0%)	243	(23.9%)
	Q4 (lowest)	10576	(24.2%)	340	(33.5%)
p-value*			<0.0001		

*p-value for chi-square test

(We analyzed the data of health interview for smoking behavior, total number is 45,522)

Supplementary table 7. Comparing difference of SES distribution between responder and non-responder (obesity)

		Response (n=42519, 99%)		Non-response (n=206, 1%)	
Education(yr)	≥13	14399	(34.9%)	47	(31.1%)
	10-12	15621	(37.8%)	63	(41.7%)
	7-9	4972	(12.0%)	26	(17.2%)
	≤6	6284	(15.2%)	15	(9.9%)
p-value*			0.063		
Income	Q1 (highest)	10535	(25.3%)	31	(16.2%)
	Q2	10516	(25.2%)	44	(23.0%)
	Q3	10453	(25.1%)	51	(26.7%)
	Q4 (lowest)	10218	(24.5%)	65	(34.0%)
p-value*			0.003		

* p-value for chi-square test

Supplementary table 8. Comparing difference of SES distribution between responder and non-responder (diabetes)

		Response (n=34257, 92%)		Non-response (n=3262, 8%)	
Education(yr)	≥13	12308	(36.0%)	670	(32.8%)
	10-12	12810	(37.5%)	752	(36.8%)
	7-9	3975	(11.6%)	258	(12.6%)
	≤6	5095	(14.9%)	363	(17.8%)
p-value*			0.001		
Income	Q1 (highest)	8652	(25.5%)	655	(21.0%)
	Q2	8561	(25.3%)	700	(22.4%)
	Q3	8517	(25.1%)	782	(25.0%)
	Q4 (lowest)	8148	(24.1%)	988	(31.6%)
p-value*			<0.001		

*p-value for chi-square test

(We analyzed only the data of KNHANES III (2005) to VI (2014) for diabetes, total number is 37,519)

Supplementary table 9. Comparing difference of SES distribution between responder and non-responder (hypertension)

		Response (n=40904, 96%)		Non-response (n=1821, 4%)	
Education(yr)	≥13	14265	(35.0%)	181	(29.4%)
	10-12	15430	(37.8%)	254	(41.3%)
	7-9	4908	(12.0%)	90	(14.6%)
	≤6	6209	(15.2%)	90	(14.6%)
p-value*			0.013		
Income	Q1 (highest)	10176	(25.3%)	390	(23.0%)
	Q2	10149	(25.2%)	411	(24.2%)
	Q3	10102	(25.1%)	402	(23.7%)
	Q4 (lowest)	9788	(24.3%)	495	(29.2%)
p-value*			<0.001		

*p-value for chi-square test

Supplementary table 10. Comparing difference of SES distribution between responder and non-responder (hypercholesterolemia)

		Response (n=34226, 91%)		Non-response (n=3293, 9%)	
Education(yr)	≥13	12298	(36.0%)	680	(32.8%)
	10-12	12794	(37.5%)	768	(37.0%)
	7-9	3972	(11.6%)	261	(12.6%)
	≤6	5093	(14.9%)	365	(17.6%)
p-value*					
Income	Q1 (highest)	8645	(25.5%)	662	(21.0%)
	Q2	8552	(25.3%)	709	(22.5%)
	Q3	8508	(25.1%)	791	(25.1%)
	Q4 (lowest)	8142	(24.1%)	994	(31.5%)
p-value*					

*p-value for chi-square test

(We analyzed only the data of KNHANES III (2005) to VI (2014) for hypercholesterolemia, total number is 37,519)

BMJ Open

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population: a cross sectional study using data from the Korea National Health and Nutrition Examination Survey, 2001-2014

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2016-014070.R3
Article Type:	Research
Date Submitted by the Author:	17-Feb-2017
Complete List of Authors:	Kim, Yoon Jung; Hangang Sacred Heart Hospital, Hallym University Medical Center Lee, Ji Sung; Asan Medical Center, University of Ulsan College of Medicine, Clinical Research Center Park, Juri; Hallym University Kangdong Sacred Heart Hospital, Division of Endocrinology and Metabolism, Department of Internal Medicine Choi, Dong Seop; Korea University College of Medicine, Department of Internal Medicine Kim, Doo Man; Hallym University Kangdong Sacred Heart Hospital, Division of Endocrinology and Metabolism, Department of Internal Medicine Lee, Kee-Hyoung ; Korea University College of Medicine, Pediatrics Kim, Ho Yeon ; Inha University Hospital, Department of Obstetrics and Gynecology Kim, Sin Gon; Korea University College of Medicine, Department of Internal Medicine Lee, Juneyoung; Korea University College of Medicine, Biostatistics
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Cardiovascular medicine, Health policy, Public health
Keywords:	Health inequality, cardiovascular disease, trend, cardiovascular disease risk factors

Trends in socioeconomic inequalities in five major risk factors for cardiovascular disease in the Korean population: a cross sectional study using data from the Korea National Health and Nutrition Examination Survey, 2001-2014

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Word count: 3499

ABSTRACT

Objectives: To examine trends in socioeconomic inequalities in major cardiovascular disease (CVD) risk factors among the Korean population

Design: Cross-sectional study

Setting: A nationally representative population survey database

Participants: A total of 42,725 Koreans, aged 25-64 years, who participated in the Korean National Health and Nutrition Examination Survey (KNHANES) II (2001) to VI (2013-2014)

Main outcome measures: Trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia)

Results Gender differences were noted in the time trends in socioeconomic inequalities in smoking, obesity, diabetes and hypertension. Among men, low socioeconomic status (SES) was associated with higher prevalence of smoking, but not with obesity, diabetes or hypertension. The magnitudes of socioeconomic inequalities in smoking, obesity and diabetes remained unchanged, and the magnitude of the inequality in hypertension decreased over time. However, among women**,** low SES was associated with higher prevalence of smoking, obesity, diabetes and hypertension. Time trends towards increasing socioeconomic inequalities, measured by income, in smoking, obesity and diabetes were found in women. Unlike the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequality.

Conclusions SES had a stronger impact on major CVD risk factors among Korean women than men. Moreover, socioeconomic inequalities in smoking, obesity and diabetes worsened among Korean women over time. Public policies to prevent smoking, obesity and diabetes in

women with lower SES are needed to address inequalities.

Keywords: trend, health inequality, cardiovascular disease, cardiovascular disease risk factors

Strengths and limitations of the study

- The strength of this study is that a nationally representative sample was used as the study population.
- The limitation of this study is that a period longer than 14 years could not be used for the investigation of socioeconomic inequalities, as data from KNHANES I (1998) were excluded due to a lack of reliability and there was no available nationally representative data before 1998.
- The steady decline of response rates in the KNHANES could result in underestimation of inequalities.

INTRODUCTION

Socioeconomic status (SES) has shown inverse associations with cardiovascular disease (CVD) in most industrialised Western countries, such that disadvantaged groups experience higher risks for CVD.[1-2] A considerable portion of the association between SES and CVD has been attributed to the combined effects of inequalities in health-related behaviours, environmental conditions, social structures and contact with and delivery of healthcare services.[3] As CVD mortality and morbidity contribute sizeable proportions to overall health inequality, attempts to reduce these causes of death are public health concerns.[4] Previous studies have shown that a greater decline in the prevalence of CVD risk factors among higher SES groups widened the gap among SES groups over time in the US.[5-6] However, studies in England and Australia failed to provide strong evidence that socioeconomic inequalities in CVD risk factors had increased in recent decades.[7-8]

Korea, a recently developed country, has experienced rapid socioeconomic growth. The per capita gross national income has increased 2.5-fold over the past 14 years (from $11.000 US in 2001 to $27,000 US in 2014), but the gap in socioeconomic circumstances has widened during this period.[9-10] Thus, it remains unclear whether the increased overall wealth has improved the health status of all segments of the population.

To our knowledge, no previous study has examined time trends in socioeconomic inequalities with regard to major CVD risk factors in Koreans. The purpose of this study was to examine recent national trends in socioeconomic inequalities in five major CVD risk factors (smoking, obesity, diabetes, hypertension, hypercholesterolemia) using national survey data by gender.

METHODS

Study participants

This study was based on data from five consecutive Korean National Health and Nutrition Examination Surveys (KNHANES) conducted from 2001 to 2014. The KNHANES is a national survey that assesses the general health and nutritional status of the Korean population. A detailed description of the survey design and data collection in the KNHANES has been published before.[11] The KNHANES was initiated in 1998 but we excluded the data from KNHANES I (1998) due to a lack of reliability.[12] The response rates were 92.3%, 99.1%, 78.4%, 80.8%, and 78.6% for KNHANES II, III, IV, V, and VI, respectively. In this study, the study population was limited to adults aged 25-64 years to examine trends in socioeconomic inequalities. Considering the applicability of SES (income and education), we excluded survey participants aged younger than 25 years who may not have completed their education or have no job and those older than 64 years who were mostly economically inactive. For the four CVD risk factors (obesity, diabetes, hypertension and hypercholesterolemia), total number of participants in the analysis was 42,725, which included 5,206 participants from the KNHANES II (2001), 4,286 participants from the KNHANES III (2005), 12,407 participants from the KNHANES IV (2007-2009), 12,977 participants from the KNHANES V (2010-2012), and 7,849 participants form the KNHANES VI (2013-2014) (Fig. 1). The total number of participants including in the smoking analysis was 45,522, which is, different from the number included in the analysis of other risk factors because health interview data, instead of health examination data, were used to determine subjects' smoking status. We composed the five data sets for each CVD risk factor individually, excluding the data with missing values for each CVD risk factor.

Health interview and health examination survey

The KNHANES consists of three components: a health interview, a health examination, and a nutrition survey. The health interview survey collects detailed information on SES (e.g. education level, household income), smoking and drinking behaviours, and healthcare utilisation. Prior diagnosis of diabetes and hypertension by a physician and current use of anti-hypertensive and anti-hyperglycaemic agents are included in the questionnaire (for example, for treatment of diabetes, "what is your treatment for diabetes mellitus?", with the following answer categories: insulin, oral hypoglycemic agents or lifestyle modification.) Height to the nearest 0.1 cm was measured using portable stadiometers. Weight to the nearest 0.1 kg was measured using a portable electronic scale. According to the standard protocol, systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured by trained nurses using a mercury sphygmomanometer (Baumanometer Desk model; Baum, NY, USA) on the right arm of the subject while sitting after at least 5 min of rest.

Blood sample collection and biochemical analysis

Venous blood samples were obtained from each participant in the morning after fasting for at least 8 h. All samples were processed according to the protocols of KNHANES. After blood collection, an 8 mL serum separating tube for analysing blood lipid level was kept at room temperature for 30 min, and the blood was subsequently centrifuged (3000 rpm, 15 min). A 2 ml sodium fluoride tube for analysing glucose levels was mixed in a roller mixer for 10 min. All blood samples were refrigerated at 2-8°C and then transported to the central laboratory. Within 24 h of blood collection, plasma concentrations of glucose and lipid were assayed

using an Advia 1650 (Siemens, NY, USA) in 2005 and 2007 and using a Hitachi Automatic Analyzer 7600 (Hitachi, Tokyo, Japan) since 2008. Since 2005, all laboratory analyses were performed according to the protocol and monitored to ensure the values met acceptable standards of precision and reproducibility in a central laboratory. Because quality control for the biochemical analysis of blood was started in 2005, we analysed the data of serum glucose and total cholesterol that were collected since 2005 in this study.

SES indicators

Education level and income were used as SES indicators. Education level was grouped into four categories: college or higher (≥13 years), high school (10-12 years), middle school (7-9 years), elementary school or less (≤6 years). The measure of income was equivalised gross household income per month, defined as total household income divided by the square root of the number of household members to adjust for the effect of the number of individuals in the household. We divided study subjects into four groups according to quartiles of equivalised household income by gender and age (Q1–Q4; Q1, highest quartile; Q4, lowest quartile).

Definition of CVD risk factors

Smoking, obesity, diabetes, hypertension and hypercholesterolemia were examined because these are major independent risk factors for CVD.[13] Cigarette smoking was defined as a "yes" answer to both of the following questions: "Have you smoked at least 100 cigarettes in your entire life?" and "Do you smoke cigarettes now?" Body mass index (BMI) was calculated as the ratio of weight to height squared (kg/m^2). Obesity was defined as a BMI of ≥25 kg/m^2, according to the re-defined criteria of the World Health Organization for obesity

in the Asia-Pacific region.[14] Based on the criteria of the World Health Organization, diabetes was defined as fasting plasma glucose of ≥126 mg/dL, a previous diagnosis of diabetes by a physician, or current use of anti-hyperglycaemic agents or insulin.[15] According to the criteria of the 7th Report of the Joint National Committee, hypertension was defined as an average SBP and/or DBP ≥140/90 mmHg or the use of anti-hypertensive agents.[16] According to the guidelines for cholesterol of the NCEP ATP III, hypercholesterolemia was defined as a plasma total cholesterol of ≥240 mg/dL or current use of cholesterol-lowering agents.[17]

Statistical analysis

The demographic characteristics of the study participants are presented as the means ± standard errors (SE) or age-adjusted prevalence (SE). Comparisons of the characteristics across survey periods were performed using analysis of variance (ANOVA) or χ^2 test, as appropriate, and χ^2 linear trend test was also used. To adjust differences in results from changes in age structure of each survey, age-adjusted prevalence was calculated using a direct standardization method based on 2010 Korea Census.

The relative index of inequality (RII), a measure of effect that permits meaningful comparisons of socioeconomic health inequalities over survey periods was computed. The RII enables direct comparisons between SES variables with regard to the proportions of the population in different categories. To obtain the RII for each indicator of SES, a score between 0 (for the highest SES) and 1 (for the lowest SES) was assigned to each category based on the proportion of subjects above the midpoint in the category. For example, if 10% of the subjects were in the highest educational category, participants in the group were

represented by the range 0-0.1 and given a score of 0.05 (half of 0.1). If 20% of the population were in the next group, participants in the group were given a score of 0.2 (0.1 plus 0.2/2). The RII was obtained by regressing the outcome on each of the SES scores and was directly interpretable for each SES indicator used to compare participants with lowest SES (1) with those with the highest SES (0). In this study, the RII of major CVD risk factors is presented using the odds ratio and 95% confidence interval computed from binary logistic regression analysis adjusted for age. Trends in the RII were examined by estimating the p value for an interaction term of SES indicator and the variables that identified the year of the data in the model. Survey year was entered into the model as a numerical value (e.g., 2001 for KNHANES II). We also calculated a slope index of inequality (SII) for each risk factor in each survey. The SII was measured using the regression coefficient (slope) for the linear relationship between the prevalence of a CVD risk factor in a socioeconomic category in the overall distribution of the SES, and relative rank of that category in the overall distribution of the SES. The regression coefficient can be interpreted as the absolute difference in prevalence across the entire SES distribution. In addition, we investigated gender and SES association in an interaction model to examine whether there was a significant difference between the trends in men and women.

As data from KNHANES were derived from stratified and multi-stage clustered probability sampling methods to represent the entire South Korean population, population weightings were also applied in the analyses. The PROC SURVEY procedure was used to apply stratification, primary sampling units and population weights. Significance levels were set at a two tailed p-value <0.05. All analyses were conducted using the SAS software version 9.4 (SAS Institute, Cary, NC).

RESULTS

The general characteristics of participants in the KNHANES II (2001) to VI (2013-2014) are shown in Table 1. The mean age of participants increased over time (41.2 ± 0.2 to 43.8 ± 0.2 years and 41.6 ± 0.2 to 44.2 ± 0.2 years for men and women, respectively). The proportion of participants with college or higher education (≥13 years) increased gradually, from 39% to 47% for men and from 24% to 39% for women from 2001 to 2014. There were significant interaction effects between gender and SES on RII except for hypercholesterolemia. The p-values for gender by education interaction were <0.001, <0.001, <0.001, <0.001 and 0.768 for smoking, obesity, diabetes, hypertension and hypercholesterolemia, respectively, while those for the interaction of gender by income were <0.001, <0.001, 0.033, 0.048 and 0.302, respectively. Therefore, we examined the trends in socioeconomic inequalities for major CVD risk factors by gender.

Smoking

Over the past 14 years, the age-adjusted smoking prevalence decreased significantly, from 64% to 47% in men, but it did not change in women (Table 1). Low SES was associated with a high prevalence of smoking in both genders (Table 2). Among Korean men, time trends in socioeconomic inequalities in smoking prevalence by education and income levels were generally stable during 2001-2014. In contrast, a significantly increasing trend in socioeconomic inequalities with regard to smoking prevalence was noted among women (Table 2).

Table 1 General characteristics of the study population (25-64 years) from 2001 to 2014

	KNHANES*					P-value†
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14	
Men						
n	3164	2868	5318	5501	3315	
Age	41.2±0.2	41.1±0.3	42.4±0.2	43.1±0.2	43.8±0.2	<0.001
BMI	23.9±0.1	24.2±0.1	24.3±0.1	24.3±0.1	24.6±0.1	<0.001
Education (yr)						<0.001
≤6	9.4 (0.8)	8.3 (0.6)	9.6 (0.5)	8.3 (0.5)	7.2 (0.6)	
7-9	12.1 (0.7)	10.0 (0.7)	10.5 (0.5)	10.1 (0.5)	8.8 (0.6)	
10-12	39.8 (1.2)	42.4 (1.2)	39.4 (0.9)	38.6 (0.8)	36.9 (1.1)	
≥13	38.7 (1.6)	39.2 (1.4)	40.5 (1.0)	43.0 (0.9)	47.1 (1.2)	
Income‡						0.234
Q1(highest)	22.3 (1.3)	26.7 (1.2)	24.8 (0.8)	26.5 (0.8)	25.0 (1.0)	
Q2	24.0 (1.0)	25.2 (1.0)	24.2 (0.7)	25.6 (0.8)	26.0 (0.9)	
Q3	26.6 (1.0)	23.1 (0.9)	25.4 (0.7)	24.5 (0.7)	24.7 (0.9)	
Q4(lowest)	27.0 (1.4)	25.0 (1.3)	25.7 (1.0)	23.5 (0.8)	24.2 (1.2)	
Prevalence§						
Smoking	64.0 (0.02)	54.8 (0.02)	49.0 (0.02)	49.7 (0.02)	47.1 (0.02)	0.03
Obesity	33.9 (0.02)	38.4 (0.02)	39.7 (0.02)	38.8 (0.02)	41.4 (0.02)	0.038
Diabetes	7.3 (0.01)	9.2 (0.01)	8.9 (0.01)	8.8 (0.01)	9.9 (0.01)	0.076
Hypertension	27.9 (0.02)	26.8 (0.01)	23.3 (0.01)	26.0 (0.01)	25.6 (0.01)	0.404
Hypercholesterolemia	8.6 (0.01)	7.4 (0.01)	9.5 (0.01)	11.7 (0.01)	12.6 (0.01)	0.062
Women						
n	3509	3276	7048	7410	4497	
Age	41.6±0.3	41.6±0.3	42.7±0.2	43.5±0.2	44.2±0.2	<0.001
BMI	23.4±0.1	23.4±0.1	23.2±0.1	23.3±0.1	23.1±0.1	0.018
Education						<0.001
≤6	19.2 (1.1)	17.3 (0.9)	17.2 (0.6)	15.5 (0.6)	12.5 (0.7)	
7-9	14.6 (0.7)	13.2 (0.7)	12.3 (0.5)	11.6 (0.5)	10.2 (0.5)	
10-12	42.2 (1.1)	42.0 (1.3)	40.6 (0.7)	38.9 (0.8)	38.3 (0.9)	
≥13	24.1 (1.4)	27.6 (1.5)	29.9 (0.9)	34.0 (0.9)	39.1 (1.1)	
Income‡						0.133
Q1(highest)	23.1 (1.3)	25.9 (1.1)	24.3 (0.8)	27.6 (0.8)	24.7 (0.9)	
Q2	24.0 (0.9)	25.7 (1.0)	25.3 (0.7)	25.8 (0.7)	25.0 (0.9)	
Q3	26.1 (0.9)	24.2 (0.9)	25.2 (0.7)	24.4 (0.7)	25.1 (0.9)	
Q4(lowest)	26.9 (1.5)	24.2 (1.3)	25.2 (0.9)	22.3 (0.7)	25.2 (1.2)	
Prevalence§						
Smoking	3.7 (0.01)	5.4 (0.01)	6.0 (0.01)	6.9 (0.01)	5.8 (0.01)	0.125
Obesity	30.8 (0.02)	29.7 (0.02)	26.8 (0.01)	28.0 (0.01)	24.4 (0.01)	0.036
Diabetes	5.9 (0.01)	5.3 (0.01)	5.7 (0.01)	5.4 (0.01)	5.4 (0.01)	0.177
Hypertension	17.7 (0.01)	16.9 (0.01)	15.3 (0.01)	16.1 (0.01)	14.2 (0.01)	0.034
Hypercholesterolemia	8.8 (0.01)	7.0 (0.01)	10.1 (0.01)	12.5 (0.01)	11.9 (0.01)	<0.001

Values given are n, prevalence (SE) or mean ± SE
*KNHANES (Korean National Health and Nutrition Examination Survey)
†P-value by ANOVA or χ^2test
‡Quartiles based on equivalised household income
§ Age-adjusted prevalence. Small SE's are due to weighted samples, which are as large as whole population, being used for direct standardization.

Table 2 Age-adjusted odds ratios (OR) and 95% confidence interval (CI) and relative indices of inequalities (RII) in smoking by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.75 (1.45-2.12)	1.86 (1.53-2.25)	1.57 (1.37-1.81)	1.47 (1.27-1.71)	1.48 (1.23-1.78)
7-9	1.48 (1.14-1.93)	1.57 (1.13-2.18)	2.16 (1.72-2.71)	1.62 (1.27-2.05)	1.25 (0.92-1.72)
≤6	2.41 (1.72-3.37)	2.22 (1.62-3.05)	1.95 (1.53-2.48)	1.71 (1.32-2.22)	1.77 (1.26-2.49)
RII (95% CI)	2.73 (1.97-3.79)	2.75 (2.00-3.79)	2.74 (2.16-3.48)	2.16 (1.69-2.77)	2.17 (1.57-3.00)
P for trend			0.193		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.23 (0.97-1.55)	1.34 (1.05-1.72)	1.31 (1.11-1.56)	1.09 (0.91-1.30)	1.26 (1.00-1.59)
Q3	1.49 (1.17-1.91)	1.50 (1.21-1.86)	1.56 (1.32-1.85)	1.23 (1.01-1.49)	1.34 (1.07-1.66)
Q4(lowest)	1.74 (1.35-2.24)	1.87 (1.46-2.40)	1.79 (1.51-2.12)	1.50 (1.24-1.81)	1.43 (1.15-1.79)
RII (95% CI)	2.10 (1.53-2.89)	2.22 (1.63-3.02)	2.16 (1.74-2.68)	1.71 (1.34-2.18)	1.57 (1.19-2.08)
P for trend			0.087		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.25 (0.75-2.09)	3.69 (2.07-6.57)	3.95 (2.78-5.62)	2.80 (1.97-4.00)	4.08 (2.67-6.22)
7-9	1.55 (0.76-3.15)	4.04 (1.95-8.34)	6.47 (3.90-10.7)	6.15 (3.65-10.4)	7.75 (4.12-14.6)
≤6	1.98 (1.00-3.90)	4.12 (1.92-8.86)	7.59 (4.42-13.0)	5.52 (3.06-9.9)	9.53 (4.88-18.6)
RII (95% CI)	1.75 (0.87-3.52)	3.41 (1.78-6.55)	8.27 (5.05-13.6)	6.81 (3.86-12.0)	10.29 (5.23-20.2)
P for trend			<0.001		
Income					
Q1(highest)	1	1	1	1	1
Q2	0.53 (0.29-0.95)	1.05 (0.58-1.91)	0.95 (0.64-1.42)	0.98 (0.66-1.46)	1.54 (0.82-2.89)
Q3	0.67 (0.39-1.13)	1.50 (0.90-2.51)	1.46 (1.02-2.09)	1.48 (0.99-2.23)	2.28 (1.29-4.00)
Q4(lowest)	1.53 (0.95-2.47)	2.74 (1.68-4.46)	2.23 (1.57-3.17)	2.53 (1.75-3.65)	3.95 (2.34-6.66)
RII (95% CI)	1.92 (0.88-4.21)	4.45 (2.26-8.76)	3.36 (2.10-5.39)	4.11 (2.46-6.88)	6.27 (3.22-12.20)
P for trend			0.043		

Obesity

We found significant increased trends in the mean BMI (23.9 kg/m^2 in 2001 and 24.6 kg/m^2 in 2014, p <0.001) and the age-adjusted prevalence of obesity (34% for 2001 and 41% for 2014, p=0.038) over time in men (Table 1). In contrast, women showed decreasing trends in mean BMI and the age-adjusted prevalence of obesity (23.4 kg/m^2 in 2001 and 23.1 kg/m^2 in 2014, p=0.018, 31% in 2001 and 24% in 2014, p=0.036; Table 1). Time trends in socioeconomic inequalities in obesity were stable among men; however, a time trend toward increasing inequality in obesity by income was noted in women (1.72, 1.19-2.48 in 2001; 2.69, 2.02-3.59 in 2014, p=0.03, RII, 95% CI, respectively; Table 3).

Diabetes

The age-adjusted prevalence of diabetes did not change significantly over time in either gender (Table 1). Although no significant time trend in socioeconomic inequality for diabetes prevalence was seen in men, significantly increasing inequality in diabetes prevalence was noticed in women, especially by income (0.76, 0.36-1.58 in 2001; 2.56, 1.55-4.22 in 2014, RII, 95% CI, p=0.01, respectively; Table 4).

Hypertension

The age-adjusted prevalence of hypertension did not change significantly over time among men (Table 1). However, the age-adjusted prevalence of hypertension was decreased over time among women. There were also gender differences in the time trend with regard to socioeconomic inequalities in hypertension (Table 5). In men, socioeconomic differences

Table 3 Age-adjusted OR, 95% CI and RII in obesity by SES from 2001 to 2014

	KNHANES				
	II 2001	III 2005	IV 2007-9	V 2010-12	VI 2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	0.96 (0.78-1.20)	0.86 (0.66-1.12)	0.91 (0.79-1.04)	0.89 (0.76-1.04)	1.03 (0.86-1.23)
7-9	0.90 (0.64-1.26)	0.90 (0.57-1.44)	0.80 (0.65-1.00)	0.88 (0.67-1.14)	0.94 (0.68-1.30)
≤6	0.83 (0.55-1.23)	0.43 (0.27-0.67)	0.74 (0.58-0.93)	0.64 (0.48-0.84)	0.80 (0.57-1.11)
RII (95% CI)	0.95 (0.66-1.38)	0.63 (0.40-0.98)	0.74 (0.58-0.94)	0.79 (0.60-1.03)	0.98 (0.72-1.34)
P for trend			0.673		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.15 (0.88-1.51)	0.89 (0.63-1.26)	1,02 (0.86-1.21)	0.89 (0.73-1.08)	0.90 (0.73-1.10)
Q3	0.92 (0.70-1.20)	0.71 (0.52-0.97)	1.02 (0.84-1.23)	0.97 (0.81-1.17)	1.15 (0.91-1.44)
Q4(lowest)	1.11 (0.83-1.47)	0.76 (0.55-1.06)	0.96 (0.80-1.15)	0.74 (0.61-0.90)	0.85 (0.69-1.05)
RII (95% CI)	1.02 (0.71-1.45)	0.66 (0.43-1.02)	0.95 (0.75-1.20)	0.72 (0.57-0.92)	0.91 (0.70-1.20)
P for trend			0.778		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	2.64 (1.93-3.60)	1.99 (1.43-2.77)	1.74 (1.46-2.08)	1.90 (1.59-2.28)	1.76 (1.43-2.18)
7-9	5.53 (3.83-7.98)	2.84 (1.86-4.34)	2.49 (1.98-3.12)	2.45 (1.92-3.12)	2.92 (2.16-3.96)
≤6	3.79 (2.52-5.72)	3.42 (2.28-5.15)	3.55 (2.81-4.50)	2.65 (2.09-3.37)	3.99 (2.92-5.45)
RII (95% CI)	3.19 (2.23-4.57)	3.45 (2.17-5.47)	3.57 (2.83-4.51)	2.93 (2.29-3.73)	4.01 (2.94-5.49)
P for trend			0.617		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.17 (0.90-1.51)	1.50 (1.06-2.11)	1.05 (0.87-1.26)	1.32 (1.07-1.63)	1.65 (1.29-2.10)
Q3	1.30 (0.97-1.73)	1.43 (1.03-1.98)	1.48 (1.24-1.77)	1.51 (1.25-1.83)	1.97 (1.58-2.47)
Q4(lowest)	1.53 (1.15-2.03)	1.63 (1.16-2.29)	1.61 (1.34-1.93)	1.88 (1.54-2.29)	2.21 (1.74-2.81)
RII (95% CI)	1.72 (1.19-2.48)	1.73 (1.15-2.61)	2.03 (1.61-2.56)	2.21 (1.73-2.83)	2.69 (2.02-3.59)
P for trend			0.032		

Table 4 Age-adjusted OR, 95% CI and RII in diabetes by SES from 2005 to 2014

	KNHAENS			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education (yr)				
≥13	1	1	1	1
10-12	1.21 (0.72-2.03)	0.98 (0.74-1.28)	1.39 (1.05-1.85)	1.14 (0.82-1.57)
7-9	1.20 (0.64-2.25)	1.05 (0.73-1.52)	1.41 (0.96-2.06)	1.13 (0.71-1.81)
≤6	1.42 (0.77-2.59)	0.92 (0.64-1.32)	1.30 (0.88-1.90)	1.06 (0.65-1.73)
RII (95% CI)	1.41 (0.72-2.77)	0.91 (0.59-1.40)	1.38 (0.91-2.09)	1.09 (0.64-1.85)
P for trend		0.838		
Income				
Q1(highest)	1	1	1	1
Q2	0.53 (0.30-0.93)	1.12 (0.81-1.56)	0.76 (0.54-1.07)	0.86 (0.58-1.30)
Q3	0.84 (0.49-1.43)	0.96 (0.69-1.32)	0.90 (0.64-1.27)	1.06 (0.73-1.55)
Q4(lowest)	0.93 (0.57-1.53)	1.48 (1.09-2.01)	1.06 (0.77-1.46)	1.34 (0.92-1.95)
RII (95% CI)	1.08 (0.53-2.18)	1.53 (1.02-2.30)	1.17 (0.76-1.79)	1.55 (0.95-2.56)
P for trend		0.557		
Women				
Education (yr)				
≥13	1	1	1	1
10-12	2.69 (1.11-6.53)	2.04 (1.28-3.23)	2.10 (1.30-3.40)	1.38 (0.89-2.12)
7-9	3.30 (1.00-10.9)	1.76 (1.02-3.05)	2.23 (1.26-3.96)	1.76 (1.02-3.02)
≤6	4.33 (1.42-13.3)	3.29 (1.93-5.59)	2.85 (1.62-5.02)	1.68 (0.99-2.87)
RII (95% CI)	3.69 (0.99-13.8)	3.33 (1.99-5.57)	2.61 (1.57-4.35)	1.92 (1.14-3.23)
P for trend		0.254		
Income				
Q1(highest)	1	1	1	1
Q2	0.86 (0.46-1.59)	1.06 (0.70-1.59)	1.84 (1.21-2.79)	1.13 (0.72-1.78)
Q3	1.10 (0.62-1.98)	1.75 (1.23-2.50)	2.36 (1.55-3.57)	1.23 (0.79-1.91)
Q4(lowest)	0.71 (0.39-1.31)	1.99 (1.39-2.87)	2.56 (1.72-3.82)	2.04 (1.38-3.01)
RII (95% CI)	0.76 (0.36-1.58)	2.80 (1.77-4.42)	2.90 (1.89-4.47)	2.56 (1.55-4.22)
P for trend		0.015		

Table 5 Age-adjusted OR, 95% CI and RII of hypertension by SES from 2001 to 2014

	KNHANES				
	II	III	IV	V	VI
	2001	2005	2007-9	2010-12	2013-14
Men					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.43 (1.08-1.89)	1.03 (0.75-1.40)	1.03 (0.86-1.25)	1.15 (0.97-1.38)	0.97 (0.78-1.22)
7-9	1.22 (0.84-1.78)	1.50 (0.96-2.36)	0.98 (0.77-1.24)	1.12 (0.87-1.44)	0.93 (0.69-1.24)
≤6	1.17 (0.77-1.79)	1.31 (0.85-2.02)	1.08 (0.84-1.40)	1.15 (0.89-1.49)	1.01 (0.70-1.47)
RII (95% CI)	1.34 (0.88-2.03)	1.41 (0.90-2.20)	1.08 (0.82-1.42)	1.16 (0.88-1.52)	0.93 (0.66-1.32)
P for trend			0.133		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.21 (0.86-1.69)	0.87 (0.59-1.29)	1.09 (0.88-1.35)	1.13 (0.91-1.42)	1.28 (0.95-1.71)
Q3	1.10 (0.76-1.59)	0.95 (0.70-1.29)	1.11 (0.89-1.39)	1.11 (0.89-1.37)	1.09 (0.83-1.43)
Q4(lowest)	1.58 (1.14-2.19)	1.23 (0.90-1.69)	1.23 (0.99-1.54)	1.11 (0.89-1.38)	1.05 (0.80-1.39)
RII (95% CI)	1.64 (1.09-2.49)	1.37 (0.91-2.06)	1.30 (0.99-1.71)	1.11 (0.85-1.46)	0.99 (0.71-1.39)
P for trend			0.042		
Women					
Education (yr)					
≥13	1	1	1	1	1
10-12	1.55 (0.93-2.61)	1.91 (1.14-3.18)	2.21 (1.62-3.02)	1.69 (1.32-2.17)	1.80 (1.30-2.47)
7-9	2.64 (1.47-4.76)	2.90 (1.60-5.25)	2.50 (1.76-3.55)	2.15 (1.58-2.92)	2.59 (1.78-3.77)
≤6	1.79 (0.99-3.24)	3.18 (1.68-5.99)	2.69 (1.91-3.80)	2.45 (1.83-3.30)	3.06 (2.10-4.46)
RII (95% CI)	1.48 (0.89-2.46)	2.11 (1.21-3.69)	1.93 (1.38-2.70)	2.15 (1.56-2.97)	2.91 (1.98-4.29)
P for trend			0.060		
Income					
Q1(highest)	1	1	1	1	1
Q2	1.48 (1.06-2.07)	1.37 (0.92-2.05)	0.99 (0.80-1.23)	1.04 (0.82-1.33)	1.44 (1.04-1.98)
Q3	1.15 (0.78-1.69)	1.33 (0.92-1.93)	1.25 (1.00-1.55)	1.29 (1.01-1.65)	2.33 (1.74-3.13)
Q4(lowest)	1.29 (0.85-1.94)	1.50 (0.99-2.28)	1.39 (1.11-1.76)	1.41 (1.11-1.78)	1.73 (1.28-2.36)
RII (95% CI)	1.22 (0.73-2.04)	1.62 (0.97-2.71)	1.63 (1.20-2.22)	1.65 (1.23-2.21)	2.32 (1.63-3.30)
P for trend			0.056		

decreased with income over the past 14 years (1.64, 1.09-2.49 in 2001; 0.99, 0.71-1.39 in 2014, RII, 95% CI, p=0.04), whereas inequalities were increased with marginal significance among women during the same period (1.48, 0.89-2.46 in 2001; 2.91, 1.98-4.29 in 2014, RII, 95% CI, p=0.06, by education; 1.22, 0.73-2.04 in 2001; 2.32, 1.63-3.30 in 2014, RII, 95% CI, p=0.056, by income, respectively; Table 5).

Hypercholesterolemia

The age-adjusted prevalence of hypercholesterolemia among men increased with marginal statistical significance. The age-adjusted prevalence of hypercholesterolemia among women increased over time (Table 1). There was no significant association between SES and hypercholesterolemia in either gender (Table 6).

DISCUSSION

The results of this study reflect gender differences not only in the relationships between major CVD risk factors and SES, but also in the linear time trends in socioeconomic inequalities in major CVD risk factors among Koreans. Among men, no major CVD risk factor, except for smoking showed significant associations with SES. Indeed, socioeconomic inequalities for major CVD risk factors were stable over time and inequality for hypertension decreased over the past 14 years. However, women with a lower SES had higher risks of smoking, obesity, diabetes and hypertension than did those with a higher SES. Increasing trends in socioeconomic inequalities in smoking, obesity and diabetes, especially measured by income, were noted in Korean women. In contrast to the other CVD risk factors, hypercholesterolemia was not associated with socioeconomic inequalities in either gender.

Table 6 Age-adjusted OR, 95% CI and RII of hypercholesterolemia by SES from 2005 to 2014

	KNHANES			
	III	IV	V	VI
	2005	2007-9	2010-12	2013-14
Men				
Education(yr)				
≥13	1	1	1	1
10-12	1.12 (0.68-1.82)	1.06 (0.82-1.36)	1.12 (0.88-1.43)	1.08 (0.81-1.42)
7-9	0.72 (0.29-1.79)	1.16 (0.80-1.69)	1.05 (0.77-1.44)	0.91 (0.54-1.52)
≤6	1.02 (0.55-1.91)	0.83 (0.57-1.23)	1.09 (0.74-1.60)	0.92 (0.58-1.45)
RII (95% CI)	0.89 (0.42-1.87)	1.00 (0.67-1.51)	1.14 (0.79-1.65)	0.93 (0.57-1.53)
P for trend		0.906		
Income				
Q1 (highest)	1	1	1	1
Q2	0.54 (0.29-1.01)	0.86 (0.63-1.17)	0.64 (0.48-0.85)	1.15 (0.81-1.64)
Q3	0.87 (0.46-1.66)	0.88 (0.66-1.18)	0.97 (0.74-1.28)	0.81 (0.56-1.18)
Q4 (lowest)	0.98 (0.54-1.78)	1.02 (0.77-1.35)	0.93 (0.71-1.21)	0.85 (0.59-1.23)
RII (95% CI)	1.14 (0.48-2.72)	1.02 (0.71-1.48)	1.08 (0.76-1.54)	0.72 (0.45-1.14)
P for trend		0.301		
Women				
Education (yr)				
≥13	1	1	1	1
10-12	0.95 (0.47-0.91)	0.76 (0.56-1.02)	1.31 (0.99-1.73)	0.84 (0.62-1.15)
7-9	0.66 (0.30-1.44)	0.74 (0.52-1.05)	1.12 (0.80-1.56)	0.95 (0.63-1.43)
≤6	0.69 (0.31-1.57)	0.83 (0.58-1.19)	1.19 (0.84-1.67)	0.95 (0.63-1.43)
RII (95% CI)	0.64 (0.27-1.53)	0.85 (0.58-1.24)	1.08 (0.75-1.54)	0.85 (0.55-1.33)
P for trend		0.499		
Income				
Q1 (highest)	1	1	1	1
Q2	0.82 (0.47-1.44)	0.88 (0.67-1.17)	0.98 (0.77-1.24)	0.79 (0.58-1.09)
Q3	0.65 (0.36-1.17)	0.97 (0.73-1.28)	0.93 (0.72-1.19)	1.29 (0.95-1.75)
Q4 (lowest)	0.96 (0.59-1.54)	1.08 (0.82-1.42)	1.12 (0.88-1.42)	1.02 (0.76-1.37)
RII (95% CI)	0.87 (0.44-1.70)	1.13 (0.79-1.61)	1.14 (0.84-1.54)	1.24 (0.85-1.81)
P for trend		0.397		

Socioeconomic inequalities in CVD risk factors and disease-related mortality are well known in industrialised Western countries and are now being found in many developing countries as well.[1-2, 18-19] However, there has been relatively little research examining time trends in socioeconomic inequalities in these CVD risk factors.[6-8] To our knowledge, this is the first report on trends in socioeconomic inequalities in major CVD risk factors in an Asian nation.

In this study, distinct gender differences in time trend for smoking prevalence were found between Korean men and women, which is consistent with trends in other Asian countries, such as China and Taiwan.[20−21] Over the past 14 years, the smoking prevalence in men decreased, but that among women did not change significantly. Consistent with previous reports, our study showed that Koreans with a lower SES had higher smoking prevalence than those with a higher SES in both gender.[22-23] However, our study further showed gender differences in the time trend of smoking inequality. Based on the RII trend, the trend in inequality was stable among men, but the socioeconomic gap among women widened. There has been significant progress with anti-smoking policies in Korea in recent years. In 1995, the Health Promotion Act was enacted and restricted smoking in public buildings and places. In 2004, a significant increase in taxation of tobacco products began.[24] We suspected that these policies may have been effective among men in all socioeconomic groups, but they were ineffective for women with lower SES.

Over the past 14 years, the prevalence of obesity has increased in men, but it has decreased in women. Among men, SES was not associated with the prevalence of obesity; however, lower SES was associated with a higher prevalence of obesity in women, reflecting gender differences in attitudes towards body image in Korea.[25] Men and women could have different attitudes toward body weight status and may use different methods for controlling body weight. As societies develop, women tend to acquire a more negative attitude towards

obesity than do men. Additionally, public attitudes are more strongly negative towards obese women than towards obese men. Thus, women are more likely to use their resources to pursue a thinner body than are men, and women tend to shift their diet and activity patterns to a healthier lifestyle more rapidly than do men.[26-27]

The prevalence of diabetes did not change in either gender during the study period. Our study found gender differences in association between SES and the prevalence of diabetes, which is consistent with previous studies that reported the influence of SES on the risk of diabetes was more pronounced in women than in men.[19, 28-30] To our knowledge, there is no previous study investigating time trends in socioeconomic inequalities for diabetes in Koreans. The inequality in diabetes among women, measured by income, increased during the past 14 years, which is consistent with previous studies in other countries.[31-32] Although the reasons for this gender difference remain unclear, several plausible explanations that relate low SES to an increased risk of diabetes in women can be proposed. Socioeconomic inequalities may cause differing lifestyle behaviours, such as alcohol intake and physical activity. Women with a lower SES have higher risk of harmful alcohol consumption, smoking and lack of physical activity.[3, 33-34] It may also be related to less social support and poorer access to healthcare services, leading to lower levels of the detection and treatment of diabetes and its associated risk factors.[35] Finally, women with a lower SES may have poor eating habits, such as a less intake of fruits and vegetables.[36]

During the study period, the prevalence of hypertension did not change among men, but decreased among women. The pattern of associations between SES and risk of hypertension differed by gender, which is consistent with a previous study.[37] The influence of low SES on hypertension was more prominent and socioeconomic inequalities widened with marginal statistical significance in women during study period. In contrast, the socioeconomic

inequality among men was decreased, although the reason for this alleviation of inequality was not clear. One possible explanation is that the marginally significant diminished inequality with respect to smoking in men during the study period may mitigate the inequality.

Trends in socioeconomic inequalities in obesity and diabetes among women increased by income level, but they were not significant when measured by education. Rapid social change has affected the meaning of education level; for example, the proportion of women who had an education level of college or above was 24% in KNHANES II (2001). However, it was ~40% in KNHANES VI (2013-2014). Thus, caution is needed in comparing education groups across time, especially in rapidly changing societies. Additionally, it may be better to divide education levels into equal parts to investigate health inequalities.[26, 38]

Investigating the trend of RIIs was a commonly used method to assess relative measure of health inequality, but in some cases, absolute and relative measure may diverge with respect to magnitude or the direction of change in health inequality.[39] Therefore, we also examined the SIIs as absolute measures of inequalities for five major CVD risk factors, and found no difference in trends between relative and absolute inequalities (Supplementary Table 1-5).

Two strengths of our study are that study subjects were a nationally representative sample and that the time trends of the relationship between SES and five major CVD risk factors were examined using two SES measures (education level, household income). However, several limitations also be noted. First, the study was cross-sectional in nature; thus, it was difficult to determine causal relationships between SES and CVD risk factors. Second, the KNHANES is a self-report survey and therefore prone to measurement error and recall bias as well as heterogeneity in self-reported health. Third, the steady decline in response rates in the KNHANES should not be overlooked, which could result in underestimating

inequalities.[40] Moreover, item responses were possibly associated with SES because there were significantly different SES distributions between item responders and non-responders for each of risk factor (Supplementary Tables 6-10), which may have resulted in underestimation. Fourth, the generalisability of our results to whole Korean population is limited since our study included only individuals aged 25-64 years, and institutionalised older adults were excluded.[11] Finally, we could not examine longer-term trends in socioeconomic inequalities in CVD risk factors before 2001, because, following the authors' judgement, the KNHANES I (1998) survey data were excluded due to lack of reliability.

CONCLUSIONS

This study found that relationships between SES and major CVD risk factors (smoking, obesity, diabetes, hypertension) were more prominent in Korean women than men. Health inequalities, especially measured by income, for smoking, obesity and diabetes increased among Korean women over the past 14 years. Public policies should be implemented to prevent risk factors for CVD among Korean women with a lower SES.

Contributors YJK, SGK, JL and JSL developed the research questions and contributed to the development of the conceptual framework, and the interpretations of the results. YJK contributed to writing and submitting the manuscript. JSL performed the main analyses and critical revisions to the manuscript. JP provided theoretical support and DSC, DMK, KL and HYK assisted with writing the manuscript.

Funding Dr. J. Lee's research was supported by a grant of College of Medicine, Korea University, Seoul, Republic of Korea (Grant No. K1616241)

Competing interests None declared.

Ethical approval All procedures and protocols of the study were approved by the Institutional Review Board of the Korea Center for Disease Control and Prevention (KCDC) since 2007. Written informed consent regarding the survey and blood analysis has been obtained from all participants since 2001.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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Figure legends

Fig 1. Study enrollment. The enrolled study population was from the Korean National Health and Nutrition Examination Surveys (KNHANES) 2001-2014

*Smoking: data from the health interviews were analysed; total number of participants is 45,522.

†Diabetes and hypercholesterolemia: data from the of KNHANES III (2005) to VI (2014) were analysed; total number of participants is 37,519.

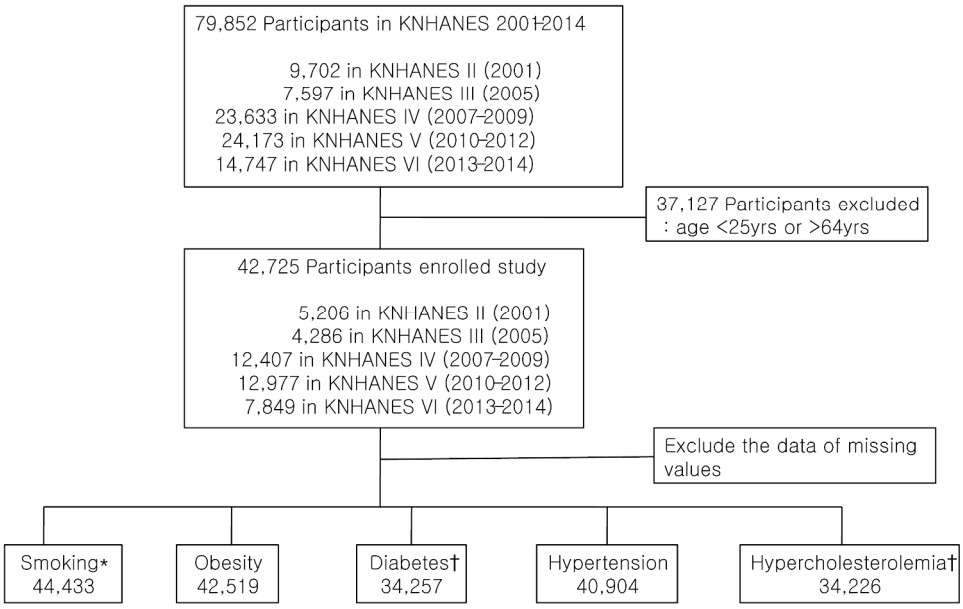

Figure 1

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Supplementary table 1. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of smoking by SES from 2001 to 2014

		KNHAENS II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	56.6(56.6-56.7)	46.6(46.5-46.7)	42.0(41.9-42.1)	42.6(42.6-42.7)	41.9(41.9-42.0)
	10-12	68.6(68.5-68.7)	59.2(59.2-59.3)	51.7(51.7-51.8)	53.6(53.5-53.6)	52.6(52.5-52.6)
	7-9	67.4(67.3-67.6)	58.2(58.0-58.5)	63.6(63.4-63.8)	63.0(62.7-63.2)	44.9(44.7-45.1)
	≤6	62.6(62.3-62.9)	51.2(50.9-51.6)	70.0(69.6-70.4)	45.8(45.6-46.1)	64.4(63.9-64.9)
	SII	9.83	8.98	36.53	13.72	20.49
	P for SII trend			0.454		
Income	Q1 (highest)	57.2(57.1-57.2)	47.1(47.0-47.1)	41.2(41.1-41.2)	45.3(45.2-45.4)	42.1(42.0-42.1)
	Q2	62.0(61.9-62.1)	54.0(53.9-54.0)	47.9(47.8-48.0)	47.1(47.0-47.1)	47.4(47.4-47.5)
	Q3	67.4(67.3-67.5)	56.3(56.2-56.3)	52.0(52.0-52.1)	50.3(50.2-50.3)	48.6(48.5-48.7)
	Q4 (lowest)	70.5(70.4-70.6)	62.1(62.1-62.2)	55.5(55.4-55.6)	55.1(55.0-55.1)	50.1(50.0-50.1)
	SII	17.96	19.08	18.92	12.99	9.98
	P for SII linear trend			0.105		
Women						
Education(yr)	≥13	2.9(2.9-3.0)	2.5(2.4-2.5)	2.8(2.8-2.8)	4.3(4.3-4.3)	2.6(2.6-2.6)
	10-12	2.9(2.8-2.9)	6.5(6.5-6.6)	7.5(7.5-7.5)	8.8(8.8-8.9)	8.2(8.2-8.3)
	7-9	3.4(3.4-3.5)	9.2(9.0-9.3)	13.2(13.1-13.3)	26.9(26.7-27.1)	19.4(19.2-19.5)
	≤6	2.6(2.6-2.6)	5.3(5.3-5.4)	15.2(15.0-15.4)	13.1(12.9-13.3)	15.1(14.9-15.3)
	SII	-0.01	5.27	16.69	20.27	20.55
	P for SII trend			0.009		
Income	Q1 (highest)	3.5(3.5-3.5)	3.5(3.5-3.5)	4.2(4.2-4.3)	4.7(4.7-4.7)	2.8(2.8-2.8)
	Q2	2.4(2.3-2.4)	3.9(3.9-4.0)	4.1(4.1-4.1)	4.6(4.5-4.6)	4.4(4.4-4.4)
	Q3	2.8(2.8-2.8)	5.2(5.2-5.2)	6.1(6.0-6.1)	6.8(6.8-6.8)	6.1(6.1-6.2)
	Q4 (lowest)	6.6(6.6-6.7)	9.0(9.0-9.1)	9.0(9.0-9.0)	10.9(10.8-10.9)	10.1(10.0-10.1)
	SII	3.82	7.22	6.48	8.39	9.38
	P for SII linear trend			0.047		

Narrow CI's are due to small SE for prevalence by using weighted samples, which are as large as whole population, for direct standardization

Supplementary table 2. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of obesity by SES from 2001 to 2014

		KNHAES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	36.4(36.3-36.5)	40.0(39.9-40.1)	41.8(41.7-41.8)	40.8(40.8-40.9)	41.4(41.3-41.4)
	10-12	33.1(33.0-33.1)	37.9(37.9-38.0)	39.9(39.8-39.9)	38.8(38.8-38.9)	42.1(42.0-42.1)
	7-9	33.2(33.1-33.3)	45.1(44.9-45.3)	41.3(41.1-41.5)	40.3(40.2-40.5)	32.9(32.8-33.1)
	≤6	28.6(28.4-28.7)	17.2(17.1-17.2)	41.2(41.1-41.5)	29.0(28.7-29.2)	47.6(47.2-48.0)
	SII	-8.22	-16.56	-0.50	-10.54	0.08
	P for SII trend			0.542		
Income	Q1 (highest)	33.9(33.8-34.0)	42.3(42.8-42.9)	40.0(40.0-40.1)	41.7(41.6-41.8)	42.2(42.2-42.3)
	Q2	35.4(35.4-35.5)	40.0(40.0-40.1)	40.5(40.4-40.6)	38.9(38.8-39.0)	39.4(39.3-39.5)
	Q3	32.0(31.9-32.1)	34.2(34.1-34.2)	40.2(40.2-40.3)	40.9(40.8-40.9)	45.6(45.5-45.6)
	Q4 (lowest)	34.3(34.3-34.4)	35.4(35.4-35.5)	39.0(38.9-39.1)	34.5(34.4-34.5)	38.5(38.4-38.5)
	SII	-0.88	-11.40	-1.36	-7.97	-2.05
	P for SII linear trend			0.940		
Women						
Education(yr)	≥13	18.0(17.9-18.1)	19.1(18.9-19.2)	16.7(16.6-16.8)	18.9(18.9-19.0)	16.1(16.0-16.1)
	10-12	30.0(29.9-30.1)	28.8(28.7-28.9)	24.8(24.7-24.8)	29.9(29.9-30.0)	24.3(24.3-24.4)
	7-9	49.8(49.7-50.0)	35.2(35.1-35.3)	31.4(31.3-31.5)	37.0(36.8-37.1)	32.2(32.1-32.4)
	≤6	38.0(37.8-38.2)	34.5(34.4-34.6)	42.9(42.7-43.2)	35.1(34.9-35.3)	50.8(50.5-51.2)
	SII	32.50	21.32	31.76	23.51	40.66
	P for SII trend			0.487		
Income	Q1 (highest)	27.2(27.1-27.3)	23.8(23.7-23.8)	22.5(22.5-22.6)	21.6(21.6-21.7)	16.2(16.1-16.2)
	Q2	30.0(29.9-30.1)	31.5(31.5-31.6)	23.5(23.5-23.6)	26.6(26.5-26.6)	24.0(24.0-24.1)
	Q3	31.3(31.2-31.4)	30.9(30.8-31.0)	29.8(29.7-29.9)	29.2(29.1-29.3)	27.6(27.6-27.7)
	Q4 (lowest)	35.0(34.9-35.0)	33.1(33.0-33.1)	31.7(31.6-31.7)	33.7(33.7-33.8)	29.9(29.8-29.9)
	SII	9.76	10.78	13.43	15.53	17.86
	P for SII linear trend			0.023		

Narrow CI's are due to small SE for prevalence by using weighted samples, which are as large as whole population, for direct standardization

Supplementary table 3. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of diabetes by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	8.1(8.1-8.1)	8.3(8.2-8.3)	7.3(7.3-7.3)	8.9(8.9-8.9)
	10-12	9.4(9.4-9.5)	8.9(8.9-8.9)	9.5(9.5-9.5)	10.3(10.3-10.4)
	7-9	11.3(11.2-11.4)	10.1(10.0-10.2)	9.1(9.0-9.1)	14.2(14.1-14.3)
	≤6	10.2(10.2-10.3)	7.6(7.6-7.7)	11.1(10.9-11.2)	9.4(9.4-9.5)
	SII	3.56	0.41	4.13	3.66
	P for SII trend		0.602		
Income	Q1 (highest)	10.4(10.3-10.4)	7.9(7.9-8.0)	9.3 (9.2-9.3)	9.5(9.5-9.6)
	Q2	6.6(6.6-6.6)	8.6(8.6-8.6)	7.3(7.3-7.3)	8.1(8.1-8.2)
	Q3	9.0(9.0-9.0)	7.8(7.8-7.9)	8.6(8.6-8.7)	9.8(9.8-9.8)
	Q4 (lowest)	10.4(10.3-10.4)	11.4(11.3-11.4)	9.8(9.7-9.8)	12.1(12.1-12.2)
	SII	1.05	3.75	1.16	3.83
	P for SII linear trend		0.576		
Women					
Education(yr)	≥13	0.6(0.6-0.6)	2.8(2.8-2.8)	3.8(3.8-3.8)	3.9(3.8-3.9)
	10-12	5.8(5.7-5.8)	5.2(5.1-5.2)	5.5(5.5-5.5)	5.6(5.6-5.7)
	7-9	7.7(7.6-7.7)	5.3(5.3-5.4)	5.0(5.0-5.1)	7.5(7.4-7.5)
	≤6	7.2(7.1-7.2)	9.2(9.1-9.2)	8.1(8.1-8.2)	7.3(7.3-7.4)
	SII	8.92	7.00	4.55	5.06
	P for SII trend		0.048		
Income	Q1 (highest)	6.1(6.1-6.1)	3.9(3.9-4.0)	2.9(2.8-2.9)	4.3(4.3-4.3)
	Q2	5.1(5.1-5.1)	4.2(4.1-4.2)	4.9(4.9-5.0)	4.6(4.6-4.6)
	Q3	6.4(6.4-6.4)	6.7(6.7-6.7)	6.4(6.3-6.4)	5.1(5.0-5.1)
	Q4 (lowest)	4.4(4.1-4.4)	7.5(7.5-7.5)	6.9(6.8-6.9)	7.9(7.9-7.9)
	SII	-1.51	5.26	5.31	4.45
	P for SII linear trend		0.016		

Narrow CI's are due to small SE for prevalence by using weighted samples, which are as large as whole population, for direct standardization

Supplementary table 4. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypertension by SES from 2001 to 2014

		KNHANES II (2001)	KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men						
Education(yr)	≥13	24.9(24.8-24.9)	24.7(24.7-24.8)	22.6(22.6-22.7)	24.7(24.6-24.7)	25.3(25.2-25.3)
	10-12	30.6(30.5-30.7)	25.9(25.8-25.9)	23.5(23.5-23.6)	27.1(27.1-27.2)	25.2(25.2-25.3)
	7-9	28.3(28.2-28.4)	27.1(27.0-27.1)	21.9(21.9-22.0)	24.9(24.8-25.0)	23.7(23.5-23.8)
	≤6	28.2(28.0-28.3)	25.0(25.0-25.1)	24.7(24.6-24.9)	29.1(28.9-29.3)	28.5(28.2-28.7)
	SII	3.96	1.52	1.37	3.75	1.79
	P for SII trend			0.888		
Income	Q1 (highest)	24.3(24.2-24.3)	26.3(26.3-26.4)	21.7(21.6-21.7)	24.4(24.4-24.5)	23.6(23.5-23.6)
	Q2	27.8(27.8-27.9)	24.9(24.8-24.9)	23.1(23.0-23.1)	27.0(27.0-27.1)	28.4(28.4-28.5)
	Q3	26.6(26.5-26.6)	26.0(25.9-26.1)	23.5(23.4-23.5)	26.5(26.4-26.5)	25.3(25.3-25.4)
	Q4 (lowest)	32.1(32.1-32.2)	30.6(30.6-30.7)	25.4(25.3-25.4)	26.4(26.3-26.4)	24.8(24.7-24.8)
	SII	8.71	5.86	4.65	2.10	0.15
	P for SII linear trend			0.038		
Women						
Education(yr)	≥13	11.8(11.811.9)	9.1(8.9-9.2)	9.2(9.2-9.3)	10.7(10.7-10.8)	9.7(9.6-9.71)
	10-12	16.7(16.7-16.8	15.1(15.1-15.2)	15.9(15.9-16.0)	15.1(15.0-15.1)	13.0(13.0-13.0)
	7-9	22.4(22.3-22.4)	19.3(19.2-19.3)	17.7(17.6-17.7)	20.5(20.4-20.6)	19.4(19.3-19.5)
	≤6	18.8(18.7-18.8)	22.4(22.3-22.5)	19.6(19.4-19.7)	20.9(20.7-21.0)	24.3(24.1-24.4)
	SII	10.78	17.02	13.10	14.39	18.80
	P for SII trend			0.060		
Income	Q1 (highest)	15.4(15.3-15.4)	14.5(14.5-14.5)	13.9(13.8-13.9)	14.1(14.1-14.2)	9.9(9.8-9.9)
	Q2	20.0(20.0-20.1)	17.7(17.6-17.7)	13.7(13.7-13.8)	14.5(14.5-14.6)	13.3(13.2-13.3)
	Q3	17.6(17.5-17.6)	17.4(17.4-17.5)	16.3(16.3-16.4)	17.1(17.0-17.1)	18.4(18.4-18.5)
	Q4 (lowest)	18.0(17.9-18.1)	18.5(18.4-18.5)	17.6(17.5-17.6)	18.2(18.1-18.2)	15.4(15.3-15.4)
	SII	2.21	4.62	5.48	5.82	8.71
	P for SII linear trend			0.057		

Narrow CI's are due to small SE for prevalence by using weighted samples, which are as large as whole population, for direct standardization

Supplementary table 5. Age-adjusted prevalence (95% CI) and slope index of inequalities (SII) of hypercholesterolemia by SES from 2005 to 2014

		KNHANES III (2005)	KNHANES IV (2007-2009)	KNHANES V (2010-2012)	KNHANES VI (2013-2014)
Men					
Education(yr)	≥13	7.1(7.1-7.1)	9.7(9.6-9.7)	11.2(11.2-11.3)	12.0(12.0-12.2)
	10-12	8.2(8.2-8.2)	9.5(9.5-9.6)	12.4(12.4-12.4)	13.3(13.2-13.3)
	7-9	4.3(4.2-4.3)	10.3(10.2-10.3)	9.8(9.8-9.9)	16.9(16.8-17.1)
	≤6	7.6(7.6-7.7)	8.9(8.8-9.0)	8.9(8.9-9.0)	12.2(12.0-12.4)
	SII	-1.40	-0.28	-3.02	2.80
	P for SII trend		0.378		
Income	Q1 (highest)	8.0(8.0-8.1)	9.9(9.9-9.9)	13.1(13.0-13.1)	13.6(13.6-13.7)
	Q2	4.8(4.8-4.9)	8.7(8.6-8.7)	8.9(8.9-8.9)	14.7(14.6-14.7)
	Q3	7.6(7.6-7.7)	8.8(8.7-8.8)	12.9(12.9-12.9)	10.9(10.9-11.0)
	Q4 (lowest)	8.9(8.9-9.0)	10.2(10.1-10.2)	12.4(12.4-12.5)	11.5(11.4-11.5)
	SII	2.27	0.34	0.86	-4.08
	P for SII linear trend		0.085		
Women					
Education(yr)	≥13	13.5(13.3-13.6)	13.1(13.0-13.2)	12.2(12.2-12.3)	12.4(12.3-12.4)
	10-12	8.4(8.3-8.4)	9.7(9.7-9.8)	13.7(13.7-13.8)	11.0(11.0-11.0)
	7-9	7.1(7.0-7.1)	10.3(10.3-10.4)	11.2(11.1-11.2)	9.8(9.7-9.8)
	≤6	5.2(5.1-5.2)	11.9(11.8-11.9)	9.8(9.8-9.9)	10.4(10.3-10.4)
	SII	-10.25	-1.89	-3.27	-3.20
	P for SII trend		0.177		
Income	Q1 (highest)	8.0(7.9-8.0)	10.2(10.2-10.3)	12.4(12.4-12.5)	11.8(11.8-11.9)
	Q2	7.4(7.4-7.4)	9.2(9.2-9.3)	12.2(12.1-12.2)	9.8(9.8-9.8)
	Q3	5.6(5.5-5.6)	10.0(10.0-10.0)	11.7(11.7-11.8)	14.2(14.2-14.3)
	Q4 (lowest)	7.6(7.6-7.7)	10.9(10.9-10.9)	13.8(13.8-13.8)	11.7(11.6-11.7)
	SII	-1.08	1.08	1.49	1.58
	P for SII linear trend		0.535		

Narrow CI's are due to small SE for prevalence by using weighted samples, which are as large as whole population, for direct standardization

Supplementary table 6. Comparing difference of SES distribution between responder and non-responder (smoking)

		Response (n=44433, 98%)		Non-response (n=1089, 2%)	
Education(yr)	≥13	15438	(36%)	36	(27.3%)
	10-12	16815	(38.1%)	49	(37.1%)
	7-9	5272	(12.0%)	19	(14.4%)
	≤6	6583	(14.9%)	28	(21.2%)
p-value*			0.093		
Income	Q1 (highest)	11112	(25.5%)	198	(19.5%)
	Q2	11032	(25.3%)	235	(23.1%)
	Q3	10915	(25.0%)	243	(23.9%)
	Q4 (lowest)	10576	(24.2%)	340	(33.5%)
p-value*			<0.0001		

*p-value for chi-square test

(We analyzed the data of health interview for smoking behaviour, total number is 45,522)

Supplementary table 7. Comparing difference of SES distribution between responder and non-responder (obesity)

		Response (n=42519, 99%)		Non-response (n=206, 1%)	
Education(yr)	≥13	14399	(34.9%)	47	(31.1%)
	10-12	15621	(37.8%)	63	(41.7%)
	7-9	4972	(12.0%)	26	(17.2%)
	≤6	6284	(15.2%)	15	(9.9%)
p-value*			0.063		
Income	Q1 (highest)	10535	(25.3%)	31	(16.2%)
	Q2	10516	(25.2%)	44	(23.0%)
	Q3	10453	(25.1%)	51	(26.7%)
	Q4 (lowest)	10218	(24.5%)	65	(34.0%)
p-value*			0.003		

* p-value for chi-square test

Supplementary table 8. Comparing difference of SES distribution between responder and non-responder (diabetes)

		Response (n=34257, 92%)		Non-response (n=3262, 8%)	
Education(yr)	≥13	12308	(36.0%)	670	(32.8%)
	10-12	12810	(37.5%)	752	(36.8%)
	7-9	3975	(11.6%)	258	(12.6%)
	≤6	5095	(14.9%)	363	(17.8%)
p-value*			0.001		
Income	Q1 (highest)	8652	(25.5%)	655	(21.0%)
	Q2	8561	(25.3%)	700	(22.4%)
	Q3	8517	(25.1%)	782	(25.0%)
	Q4 (lowest)	8148	(24.1%)	988	(31.6%)
p-value*			<0.001		

*p-value for chi-square test

(We analyzed only the data of KNHANES III (2005) to VI (2014) for diabetes, total number is 37,519)

Supplementary table 9. Comparing difference of SES distribution between responder and non-responder (hypertension)

		Response (n=40904, 96%)		Non-response (n=1821, 4%)	
Education(yr)	≥13	14265	(35.0%)	181	(29.4%)
	10-12	15430	(37.8%)	254	(41.3%)
	7-9	4908	(12.0%)	90	(14.6%)
	≤6	6209	(15.2%)	90	(14.6%)
p-value*			0.013		
Income	Q1 (highest)	10176	(25.3%)	390	(23.0%)
	Q2	10149	(25.2%)	411	(24.2%)
	Q3	10102	(25.1%)	402	(23.7%)
	Q4 (lowest)	9788	(24.3%)	495	(29.2%)
p-value*			<0.001		

*p-value for chi-square test

Supplementary table 10. Comparing difference of SES distribution between responder and non-responder (hypercholesterolemia)

		Response (n=34226, 91%)		Non-response (n=3293, 9%)	
Education(yr)	≥13	12298	(36.0%)	680	(32.8%)
	10-12	12794	(37.5%)	768	(37.0%)
	7-9	3972	(11.6%)	261	(12.6%)
	≤6	5093	(14.9%)	365	(17.6%)
p-value*			<0.001		
Income	Q1 (highest)	8645	(25.5%)	662	(21.0%)
	Q2	8552	(25.3%)	709	(22.5%)
	Q3	8508	(25.1%)	791	(25.1%)
	Q4 (lowest)	8142	(24.1%)	994	(31.5%)
p-value*			<0.001		

*p-value for chi-square test

(We analyzed only the data of KNHANES III (2005) to VI (2014) for hypercholesterolemia, total number is 37,519)

STROBE 2007 (v4)Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1,3
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	3
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	5
Objectives	3	State specific objectives, including any prespecified hypotheses	5
Methods			
Study design	4	Present key elements of study design early in the paper	6
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	6-8
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	6
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	6-8
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	6-10
Bias	9	Describe any efforts to address potential sources of bias	*6-8*
Study size	10	Explain how the study size was arrived at	-
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	6-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	6
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	10
		(*e*) Describe any sensitivity analyses	10
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	6
		(b) Give reasons for non-participation at each stage	6
		(c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	6
Outcome data	15*	Report numbers of outcome events or summary measures	12
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	10-17
		(*b*) Report category boundaries when continuous variables were categorized	11-20
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	23
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	10, 11, 23
Discussion			
Key results	18	Summarise key results with reference to study objectives	16-21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	23-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	24
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	25

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.