Effects of Income Level on the Association Between Hypertension and Depression: 2010-2017 Korea National Health and Nutrition Examination Survey

San Kang, Hyeon Chang Kim

Department of Preventive Medicine, Yonsei University College of Medicine, Seoul, Korea

Objectives: This study analyzed the associations of hypertension (HTN) with symptoms and diagnosis of depression by income level among Korean adults.

Methods: This study was based on the 2010-2017 Korea National Health and Nutrition Examination Survey data; a total of 29 425 adults (aged 20 years or older) were analyzed. HTN was defined as a systolic blood pressure $\geq$ 140 mmHg, diastolic blood pressure $\geq$ 90 mmHg, or use of hypertensive medications. Depression symptoms were evaluated based on a questionnaire about depression-related symptoms. A depression diagnosis was defined based on questionnaire responses indicating that a participant had been diagnosed with depression. Household income was divided into higher or lower income ranges based on the median income of the participants. Multiple logistic regression analyses were performed to assess the associations between HTN and depression symptoms/diagnosis in the higher-income and lower-income groups.

Results: In the higher-income group, the odds ratio (OR) for the association between HTN and depression symptoms was 1.15 (95% confidence interval [CI], 0.97 to 1.37), and the OR for the association between HTN and depression diagnosis was 1.41 (95% CI, 1.13 to 1.76). In the lower-income group, the OR for the association between HTN and depression symptoms was 1.18 (95% CI, 1.04 to 1.34), whereas the OR for the association between HTN and depression diagnosis was 0.82 (95% CI, 0.70 to 0.97).

Conclusions: The associations of HTN with symptoms and diagnosis of depression differed by income level.

Key words: Hypertension, Depression, Income, Social class

INTRODUCTION

The global prevalence of hypertension (HTN) in 2010 was 31.1%, corresponding to approximately 1.39 billion people with HTN [1]. A study using the Korea National Health and Nutrition Examination Survey (KNHANES) between 2010 and 2014 reported that the lifetime prevalence of HTN in Koreans was 34.6% in male and 30.8% in female [2]. The World Health Organization reported that the prevalence of depression worldwide was 4.4% in 2015 [3]. According to a study published in 2017, the point prevalence of depression in Korea was 6.7% [4].

Recently, many studies have sought to explain the connection between physical and mental diseases. Cardiovascular disease was reported to be associated with severe mental illness [5]. A study using Australia's National Survey of Mental Health and

Wellbeing reported that patients with chronic conditions such as diabetes, asthma, coronary artery disease, stroke, cancer, and arthritis had a higher prevalence of affective or anxiety disorders than those who did not. Previous studies have found significant associations between HTN and depression [6-8].

Associations between socioeconomic factors and various diseases have also been reported in many studies [9-11]. A higher risk of HTN in the lower socioeconomic class was found; this association was especially remarkable among female [12]. An analysis of the association between socioeconomic status (SES) and HTN was also conducted in the Korean population, and it was found that female with a lower household income had a higher incidence of HTN [13]. In addition, previous studies have reported associations between SES and depression [14]. One study found a higher incidence of major depressive episodes in people with a lower household or individual income [15]. Although there is a significant association between HTN and depression, the association between these 2 diseases by income level has not been analyzed.

Persons with low SES may under-report their health problems [16]. In addition, depression under-reporting can be assessed by comparing the number of patients with symptoms of depression to those who have been diagnosed with depression [17]. This study investigated whether there was a difference in the association between HTN and depression based on income level, and whether the difference was consistent for both depression-related variables (symptoms and diagnosis).

METHODS

Study Population

Our study used KNHANES data from 2010 to 2017. The KNHANES is a national program for assessing the health status of the Korean population. The KNHANES uses a complex, multistage probability sample design, which represents the total Korean population excluding institutionalized persons [18]. In the analysis of the association between HTN and depression symptoms/depression diagnosis, 13 954 participants under 20 years old, 2297 participants who did not have blood pressure (BP) measurements, 811 non-responders to the question on depression symptoms, and 14 923 non-responders to the questions on depression diagnosis were excluded from the total of 61 410 participants; the remaining 29 425 participants were analyzed.

Measurements

HTN was defined as systolic BP $\geq$ 140 mmHg or diastolic BP $\geq$ 90 mmHg based on the BP measurements or the use of an antihypertensive medication. Three measurements were made, and the second and the third measurements were averaged to determine BP.

In this study, a questionnaire related to depression was selected from the EuroQol- 5 dimension (EQ-5D), a measure of the quality of life, as an indicator of depression symptoms. The questionnaire measures health on the day of the survey and can be answered in three ways: "I am not anxious or depressed," "I am somewhat anxious or depressed," and "I am very anxious or depressed." This questionnaire asked about both depression and anxiety. However, a previous study reported that patients with depression were more likely to report problems on this questionnaire than those with anxiety [19]. In this study, participants responding "I am somewhat anxious or depressed" and "I am very anxious or depressed" were classified as having depression. Information on participants' history of physician-diagnosed depression was obtained from a questionnaire that asked whether a participant has been diagnosed with depression in the past.

Covariables included age, body mass index (BMI), household income, occupation, smoking, alcohol drinking, weekly walking days, and diabetes diagnosis. Because the prevalence of HTN increases with age, an age-adjusted analysis was performed. Participants were stratified by age into 3 groups: 20-39 years, 40-59 years, and $\geq$ 60 years. BMI was calculated as weight divided by height squared. The stratification criteria for BMI were as follows: < 20.0 kg/m², 20.0-< 25.0 kg/m², and $\geq$ 25.0 kg/m². Household income was divided into higher or lower based on the median income of the study participants. Participants were classified by occupation into three categories: white collar employment, blue collar employment, and unemployed. Smoking was categorized based on lifetime experience (yes or no). People who reported having smoked fewer than 100 cigarettes were regarded as never smokers. Alcohol drinkers were defined as people who reported drinking alcohol at least once a month in the last 1 year. As an assessment of physical activity, weekly walking days were quantified as the number of days that a person walked for at least 10 minutes at a time, and were classified into 0-1 d/wk, 2-3 d/wk, 4-5 d/wk, and 6-7 d/wk.

Statistical Analysis

The distribution of HTN and covariables according to the presence or absence of depression symptoms and depression diagnosis was assessed. Before carrying out the regression analysis, the variance inflation factor was calculated to test the multicollinearity of independent variables, and there was no multicollinearity in the model used in this study. The association between HTN and depression symptoms or diagnosis was assessed through multiple logistic regression analyses. The analyses were performed by assigning weights considering the complex sampling design. Male and female were separately analyzed because differences according to sex were found in previous studies of the association between HTN and depression [20,21]. SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA) was used for all analyses in this study.

Ethics Statement

The study protocol was approved by the Institutional Review Board of the Yonsei University College of Medicine (approval No. Y-2020-0102).

Table 1. Distribution of individual characteristics in the study population

Characteristics	Depression symptoms			Depression diagnosis		
	Yes (n=3874)	No (n=25 551)	*p*-value	Yes (n=1996)	No (n=27 429)	*p*-value
Hypertension diagnosis						
No	2281 (65.4)	17 676 (74.3)	<0.001	1247 (69.4)	18 710 (73.5)	<0.001
Yes	1593 (34.6)	7875 (25.7)		749 (30.6)	8719 (26.5)	
Sex						
Male	1092 (33.0)	10 867 (49.1)	<0.001	417 (26.6)	11 542 (48.5)	<0.001
Female	2782 (67.0)	14 684 (50.9)		1579 (73.4)	15 887 (51.5)	
Age (y)						
20-39	730 (27.8)	7214 (36.8)	<0.001	365 (27.5)	7579 (36.3)	<0.001
40-59	1197 (36.5)	9952 (41.6)		725 (42.4)	10 424 (40.9)	
≥60	1947 (35.7)	8385 (21.6)		906 (30.1)	9426 (22.8)	
Body mass index (kg/m^2)						
<20.0	551 (15.2)	3116 (12.9)	0.003	233 (12.9)	3434 (13.2)	0.184
20.0-<25.0	1990 (51.2)	13 920 (53.8)		1055 (51.4)	14 855 (53.6)	
≥25.0	1333 (33.6)	8515 (33.3)		708 (35.7)	9140 (33.2)	
Household income						
Low	2477 (59.1)	10 834 (38.2)	<0.001	1153 (55.4)	12 158 (39.7)	<0.001
High	1377 (40.9)	14 613 (61.8)		827 (44.6)	15 163 (60.3)	
Occupation						
White collar	780 (24.7)	9285 (40.8)	<0.001	386 (24.4)	9679 (39.9)	<0.001
Blue collar	785 (19.9)	6088 (23.8)		398 (20.3)	6475 (23.5)	
Unemployed	2285 (55.4)	10 077 (35.4)		1208 (55.3)	11 154 (36.6)	
Smoking						
No	2619 (65.2)	16 045 (59.5)	<0.001	1432 (65.5)	17 232 (59.8)	<0.001
Yes	1210 (34.8)	9332 (40.5)		548 (34.5)	9994 (40.2)	
Alcohol drinking						
No	2193 (51.2)	11 809 (41.3)	<0.001	1242 (55.3)	12 760 (41.6)	<0.001
Yes	1640 (48.8)	13 576 (58.7)		738 (44.7)	14 478 (58.4)	
Weekly walking days (d/wk)						
0-1	1240 (29.8)	6243 (23.2)	<0.001	569 (27.4)	6914 (23.7)	0.003
2-3	877 (23.3)	5885 (23.0)		471 (23.9)	6291 (23.0)	
4-5	640 (16.9)	4785 (19.1)		316 (16.3)	5109 (19.0)	
6-7	1091 (30.0)	8531 (34.7)		627 (32.4)	8995 (34.3)	
Diabetes diagnosis						
No	3350 (88.9)	23 260 (93.0)	<0.001	1752 (90.2)	24 858 (92.7)	<0.001
Yes	524 (11.1)	2291 (7.0)		244 (9.8)	2571 (7.3)	

Values are presented as number (%).

RESULTS

Among the participants with depression symptoms, 34.6% had HTN, while 25.7% of those without depression symptoms had HTN. Among those who were diagnosed with depression, 30.6% had HTN, while HTN was present in 26.5% of those without a depression diagnosis. Among the participants with depression symptoms, 40.9% were in the higher-income group and 59.1% were in the lower-income group. Among those who were diagnosed with depression, 44.6% were in the higher-income group and 55.4% were in the lower-income group (Table 1).

Table 2 shows the distribution of depression symptoms and diagnoses according to the characteristics of HTN and covari-

Table 2. Factors associated with depression symptoms and diagnosis

Variables	Total (n)	Depression symptoms			Depression diagnosis		
		n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)	n (%)	Unadjusted OR (95% CI)	Adjusted OR (95% CI)
Hypertension diagnosis							
No	19 957	2281 (10.4)	1.00 (reference)	1.00 (reference)	1247 (5.7)	1.00 (reference)	1.00 (reference)
Yes	9468	1593 (15.0)	1.53 (1.41, 1.67)	1.18 (1.07, 1.30)	749 (6.9)	1.23 (1.09, 1.38)	1.02 (0.89, 1.17)
Sex							
Male	11 959	1092 (8.1)	1.00 (reference)	1.00 (reference)	417 (3.4)	1.00 (reference)	1.00 (reference)
Female	17 466	2782 (14.7)	1.96 (1.80, 2.15)	2.01 (1.74, 2.31)	1579 (8.3)	2.61 (2.28, 2.98)	3.34 (2.71, 4.11)
Age (y)							
20-39	7944	730 (9.0)	1.00 (reference)	1.00 (reference)	365 (4.6)	1.00 (reference)	1.00 (reference)
40-59	11 149	1197 (10.3)	1.17 (1.04, 1.30)	1.14 (1.01, 1.28)	725 (6.2)	1.38 (1.20, 1.60)	1.30 (1.12, 1.52)
≥60	10 332	1947 (17.8)	2.19 (1.97, 2.43)	1.31 (1.15, 1.50)	906 (7.8)	1.75 (1.51, 2.03)	1.07 (0.89, 1.28)
Body mass index (kg/m^2)							
<20.0	3667	551 (13.4)	1.23 (1.09, 1.39)	1.22 (1.07, 1.38)	233 (5.9)	1.02 (0.85, 1.21)	0.92 (0.77, 1.09)
20.0-<25.0	15 910	1990 (11.1)	1.00 (reference)	1.00 (reference)	1055 (5.8)	1.00 (reference)	1.00 (reference)
≥25.0	9848	1333 (11.7)	1.06 (0.97, 1.16)	1.03 (0.94, 1.14)	708 (6.4)	1.13 (1.00, 1.27)	1.15 (1.01, 1.30)
Household income							
Low	13 311	2477 (16.9)	2.33 (2.14, 2.54)	1.81 (1.65, 1.98)	1153 (8.1)	1.89 (1.68, 2.12)	1.51 (1.33, 1.73)
High	15 990	1377 (8.0)	1.00 (reference)	1.00 (reference)	827 (4.5)	1.00 (reference)	1.00 (reference)
Occupation							
White collar	10 065	780 (7.4)	1.00 (reference)	1.00 (reference)	386 (3.8)	1.00 (reference)	1.00 (reference)
Blue collar	6873	785 (9.9)	1.38 (1.22, 1.57)	1.15 (1.01, 1.32)	398 (5.2)	1.43 (1.20, 1.69)	1.37 (1.15, 1.65)
Unemployed	12 362	2285 (17.0)	2.58 (2.32, 2.86)	1.81 (1.60, 2.03)	1208 (8.8)	2.49 (2.17, 2.86)	1.89 (1.63, 2.20)
Smoking							
No	18 664	2619 (12.5)	1.00 (reference)	1.00 (reference)	1432 (6.5)	1.00 (reference)	1.00 (reference)
Yes	10 542	1210 (10.1)	0.78 (0.72, 0.86)	1.32 (1.15, 1.51)	548 (5.2)	0.78 (0.69, 0.88)	1.89 (1.57, 2.27)
Alcohol drinking							
No	14 002	2193 (14.0)	1.00 (reference)	1.00 (reference)	1242 (7.8)	1.00 (reference)	1.00 (reference)
Yes	15 216	1640 (9.8)	0.78 (0.72, 0.86)	1.01 (0.92, 1.11)	738 (4.6)	0.58 (0.52, 0.64)	0.81 (0.71, 0.91)
Weekly walking days (d/wk)							
0-1	7483	1240 (14.4)	1.49 (1.33, 1.66)	1.36 (1.21, 1.53)	569 (6.9)	1.22 (1.05, 1.41)	1.08 (0.93, 1.26)
2-3	6762	877 (11.7)	1.17 (1.04, 1.32)	1.13 (1.00, 1.28)	471 (6.2)	1.10 (0.94, 1.27)	1.02 (0.87, 1.19)
4-5	5425	640 (10.4)	1.02 (0.90, 1.15)	1.01 (0.89, 1.15)	316 (5.2)	0.91 (0.77, 1.07)	0.88 (0.74, 1.03)
6-7	9622	1091 (10.2)	1.00 (reference)	1.00 (reference)	627 (5.7)	1.00 (reference)	1.00 (reference)
Diabetes diagnosis							
No	26 610	3350 (11.2)	1.00 (reference)	1.00 (reference)	1752 (5.9)	1.00 (reference)	1.00 (reference)
Yes	2815	524 (17.2)	1.65 (1.46, 1.86)	1.14 (1.00, 1.30)	244 (7.9)	1.39 (1.18, 1.64)	1.08 (0.90, 1.30)

OR, odds ratio; CI, confidence interval.

Table 3. Association of HTN with depression symptoms and diagnosis by income level

Variables	Higher-income					Lower-income				
	Total (n)	Depression symptoms		Depression diagnosis		Total (n)	Depression symptoms		Depression diagnosis	
		n (%)	OR (95% CI)	n (%)	OR (95% CI)		n (%)	OR (95% CI)	n (%)	OR (95% CI)
Total										
No HTN	12 234	1014 (8.3)	1.00 (reference)	580 (4.7)	1.00 (reference)	7797	1277 (16.4)	1.00 (reference)	675 (8.7)	1.00 (reference)
HTN	3880	383 (9.9)	1.15 (0.97, 1.37)	263 (6.8)	1.41 (1.13, 1.76)	5638	1220 (21.6)	1.18 (1.04, 1.34)	494 (8.8)	0.82 (0.70, 0.97)
Male										
No HTN	4747	262 (5.5)	1.00 (reference)	112 (2.3)	1.00 (reference)	2946	348 (11.8)	1.00 (reference)	149 (5.1)	1.00 (reference)
HTN	2091	128 (6.1)	1.01 (0.75, 1.37)	61 (2.9)	1.13 (0.74, 1.72)	2222	360 (16.2)	1.48 (1.17, 1.87)	99 (4.5)	0.80 (0.55, 1.15)
Female										
No HTN	7487	752 (10.0)	1.00 (reference)	468 (6.3)	1.00 (reference)	4851	929 (19.2)	1.00 (reference)	526 (10.8)	1.00 (reference)
HTN	1789	255 (14.3)	1.27 (1.03, 1.58)	202 (11.3)	1.59 (1.22, 2.07)	3416	860 (25.2)	1.03 (0.89, 1.20)	395 (11.6)	0.82 (0.68, 0.99)

All covariables (sex, age, body mass index, occupation, smoking, alcohol drinking, weekly walking days, diabetes diagnosis) are adjusted.
HTN, hypertension; OR, odds ratio; CI, confidence interval.

ables before dividing the population by income level; in addition, it also shows the results of the regression analysis between HTN and depression. Among the participants with HTN, 15.0% had depression symptoms and 6.9% had a depression diagnosis. In male, 8.1% had depression symptoms and 3.4% had a depression diagnosis. In female, 14.7% had depression symptoms and 8.3% had a depression diagnosis. In the lower-income group, 16.9% had depression symptoms and 8.1% had a depression diagnosis. In the higher-income group, 8.0% had depression symptoms and 4.5% had a depression diagnosis. Before adjusting for the covariables, the odds ratio (OR) for the association between HTN and depression symptoms was 1.53 (95% confidence interval [CI], 1.41 to 1.67), and the OR for the association between HTN and depression diagnosis was 1.23 (95% CI, 1.09 to 1.38). After adjusting for the covariables, the OR for the association between HTN and depression symptoms was 1.18 (95% CI, 1.07 to 1.30), and the OR for the association between HTN and depression diagnosis was 1.02 (95% CI, 0.89 to 1.17).

Table 3 shows the associations of depression symptoms and depression diagnoses with HTN after dividing the study population based on household income. The OR for the association between HTN and depression symptoms was 1.15 (95% CI, 0.97 to 1.37) in the higher-income group, and 1.18 (95% CI, 1.04 to 1.34) in the lower-income group. The OR for the association between HTN and depression diagnosis was 1.41 (95% CI, 1.13 to 1.76) in the higher income group and 0.82 (95% CI: 0.70 to 0.97) in the lower income group. HTN was positively associated with depression symptoms, regardless of income level, although the strength of the association varied in the total, male, and female population. However, the association between HTN and depression diagnosis showed opposite directions according to income level. The two conditions were positively associated in the higher-income group, but inversely associated in the lower-income group. When the study group was stratified by educational level, statistically non-significant but similar results were obtained (Supplemental Material 1). The associations of other covariables with depression symptoms and depression diagnosis by income level are also presented in the Supplemental Materials 1- 6.

DISCUSSION

In this study of nationally representative data, a positive association was found between HTN and depression symptoms in both the higher-income and lower-income groups. However, HTN and depression diagnosis showed a positive association in the higher-income group, but an inverse association in the lower-income group.

Previous studies on the association between HTN and depression, or on the influence of SES on these two diseases, were the basis for this study. A cohort study reported that the incidence of HTN was significantly higher in people with depression or anxiety [22]. The risk of depression was also shown to be higher in people with treated HTN. A cross-sectional study that analyzed elderly individuals showed a positive association between HTN and clinically significant symptoms of depression [6]. Another previous study reported that the effects of the sympathetic nervous system might be the cause of the positive association between HTN and depression [23].

A study conducted in the United States and Japan reported a higher risk of depression symptoms in groups with lower household income [24]. In addition, a previous study reported that the risk of a depression diagnosis was higher in groups with relatively few financial assets [25].

Although previous studies focused on the overall association between HTN and depression, this study analyzed the association by categorizing depression into symptoms and diagnosis. In addition, this study divided the population by income level, and found that the association between HTN and depression in the higher-income group was consistently positive, while conflicting relationships were found in the lower-income group.

It is thought that the different relationships found in this study between HTN and depression symptoms or diagnosis reflect a relatively low prevalence of depression diagnoses in the lower-income group. Based on the results of previous studies that reported a positive association between HTN and depression, the prevalence of depression diagnoses in the higher-income group may be at an appropriate level.

There may be two reasons for the lower prevalence of depression diagnoses in the lower-income group. One reason may that the lower-income group may lack of awareness of depression, thereby reducing the detection rate of depression and, as a result, lowering the prevalence of depression diagnoses. A previous study reported a lack of knowledge concerning symptoms of depression in individuals with a low SES [26]. Second, the lower-income group may have less access to healthcare than the higher-income group. A meta-analysis reported that low SES was associated with poor access to healthcare services [27]. A study concerning major depression reported that major depression disorder tended to be underdiagnosed in racial minorities as compared to whites [28]. In our study, an inverse association between HTN and depression was found in the lower-income group due to the relatively low detection rate of depression in that group.

Low-income individuals with HTN may be less likely to seek out medical care than high-income individuals. For patients with a physical disease such as HTN, prevention of depression is especially crucial.

A limitation of this study is recall bias, which may have affected the self-reported history of a depression diagnosis. Another potential limitation is residual confounding, although we adjusted for several factors that could affect the association between HTN and depression, such as biological characteristics, socioeconomic characteristics, health behavior, and comorbidity history. This study is also a cross-sectional analysis, and it was therefore not possible to assess the sequential association between major variables. In this study, depression symptoms were measured using 1 of the 5 questionnaires of the EQ-5D, a tool for measuring quality of life; further studies could be done using other tools for assessing depression.

HTN and depression are significantly associated with each other, and socioeconomic factors are also closely related to the two diseases [14,29]. In light of the results of this study, it is necessary to carefully evaluate depression in patients with HTN, especially in low-income persons; and policies related to improving medical access are needed for these patients.

SUPPLEMENTAL MATERIALS

Supplemental materials are available at https://doi.org/10.3961/jpmph.20.337.

CONFLICT OF INTEREST

The authors have no conflicts of interest associated with the material presented in this paper.

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AUTHOR CONTRIBUTIONS

Conceptualization: SK. Data curation: SK. Formal analysis: SK. Funding acquisition: None. Methodology: SK. Project administration: HCK. Visualization: HCK. Writing – original draft: SK. Writing – review & editing: HCK.

ORCID

San Kang *https://orcid.org/0000-0002-7416-3457*
Hyeon Chang Kim *https://orcid.org/0000-0001-7867-1240*

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