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Associations of Socioeconomic Status With Depression and Quality of Life in Patients With Hypertension: An Analysis of Data From the 2019 Community Health Survey in Korea

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Objectives: We aimed to identify the factors related to depression and quality of life in patients with hypertension by using multilevel regression analysis.

Methods: In 2019, 229 043 participants in the Korean Community Health Survey were selected as the study group. Individual factors were identified using data from the 2019 Community Health Survey. Regional factors were identified using data from the National Statistical Office of Korea. Multilevel regression analysis was conducted to find individual and local factors affecting depression and quality of life in patients with hypertension and to determine any associated interactions.

Results: As individual factors in patients with hypertension, women, those with lower education-levels, recipients of basic livelihood benefits, and those with poor dietary conditions showed stronger associations with depression and quality of life. As regional factors and individual-level variables in patients with hypertension, lower gross regional personal income, fewer doctors at medical institutions, and lower rates of participation in volunteer activities presented stronger associations with depression and quality of life. In addition, the associations of depression with gross regional personal income, the number of doctors at medical institutions, and dietary conditions were significantly stronger in patients with hypertension than in patients without hypertension. The associations of gender and employment status with quality of life were also significantly greater.

Conclusions: Policy interventions are needed to adjust health behaviors, prevent depression, and improve quality of life for patients with hypertension, especially for those with the risk factors identified in this study.

Key words: Socioeconomic status, Hypertension, Depression, Quality of life, Multilevel analysis

INTRODUCTION

The prevalence of hypertension, a common chronic disease, among adults aged 30 or older increased from 24.6% in 2007 to 29.0% in 2012 [1] and is expected to continue increasing. According to the National Statistical Office, the prevalence of hypertension decreased from 29.8% in 1998 to 24.5% in 2007, after rising from 25% to 29%. Recent increases in chronic diseases are expected to increase the social and economic burden of disease [2], though little research on this has been con-

ducted in Korea.

International studies have reported that socioeconomic determinants are associated with hypertension [3]. Furthermore, recent studies have also reported a close relationship between chronic diseases such as hypertension and the onset of depression. A recent meta-analysis by Li et al. [4] showed that 26.8% of patients with hypertension also had depression. In addition, hypertension, when compared to normal blood pressure, has been reported to be a major influencing factor that can lower health-related quality of life for patients with hypertension [5]. A comparison of the health-related quality of life in patients with hypertension to that of people with normal blood pressure found that the quality of life in patients with hypertension was significantly lower [6]. However, these studies were limited to the association between hypertension and other diseases. There is a lack of research on the associations of socioeconomic status (SES) with depression and quality of life in patients with hypertension.

Since individuals have relationships with their surroundings based on the area in which they reside, it is important to understand the effects of community characteristics on individual health and health behaviors [7]. Since it is known that regional social factors can affect health, it is important to accurately select the scope of the region and accurately conceptualize and measure the path by which regional factors can affect health by using multiplelevel analysis [8]. Logistic regression analysis was used for the their domestic study of the effects of hypertension on depression [9], and multiple regression analysis was used to identify the factors affecting health-related quality of life in patients with hypertension [10]. Moon et al. [11] conducted a multilevel analysis of the effect of individual and regional factors on depression, but did not focus on patients with hypertension. However, domestic studies continue to measure the differences between regions by analyzing regional and individual variables on the same level [12]. Few studies have utilized multilevel regression analysis; thus, most previous studies were limited because: (1) the effects of hypertension on depression and quality of life were analyzed on the same level, and (2) they lacked a multilevel analysis considering regional effects. If there are differences between regions that affect depression and quality of life, research on the factors that affect such differences is needed. A comprehensive analysis of both individual and regional factors that are associated with depression and quality of life is also warranted. In addition, it is necessary to study the associations of socioeconomic characteristics in patients with hypertension with depression and quality of life. Therefore, the aim of this study was to determine the association of socioeconomic factors and community factors in patients with hypertension with their depression and quality of life using multilevel analysis. The relationships of socioeconomic factors and hypertension with depression and quality of life were also examined.

METHODS

Study Population and Data

This study analyzed individual data and regional data. Data collected from a Community Health Survey performed in 2019 in Korea were used as individual data. Subjects answered "no" or "yes" to the question "Have you ever been diagnosed with high blood pressure by a doctor?". The study sample included 65 601 people with hypertension and 163 442 people without hypertension. After excluding those with missing values, 229 043 respondents to the 2019 Community Health Survey were included in the final analysis of this study. For regional data, e-local indicators of statistical data provided by the Statistics Korea in Korea were used [13].

Dependent Variables

Depression was scored 0 for "no" and 1 for "yes" for the question, "Have you ever felt sad or hopeless enough that it interferes with your daily life for 2 consecutive weeks in the past year?". The EuroQol-5 Dimention (EQ-5D) index is a tool developed by the EuroQol Group to assess general health levels. It consists of responses to 5 items: mobility, self-care, daily activities, pain/discomfort, and anxiety/depression at 3 levels: "no problem," "some problems," and "severe problems." Weights were applied to each of these 5 items to obtain the EQ-5D index score, a health-related quality-of-life score distributed between full health (1 point) and the lowest level of health before death (-1 point). Death is scored as 0 points. Based on 25% of the total, the Quality of Life Index was categorized as 0 for "no" quality of life degradation (Quality of Life Index between 0.91 and 1.00) and 1 for a "yes" response regarding degradation (Quality of Life Index between -0.20 and 0.91).

Independent Variables

Individual variables were selected based on previous studies of their association with depression and quality of life [9,10,14-16]. Individual demographic and sociological factors included

gender, age, and socioeconomic factors such as education-level, employment status, basic livelihood benefits (yes/no), and dietary conditions. Regional variables were the socioeconomic factors of 17 cities and provinces. These factors were based on regional impact factor studies using majority-level analysis and included gross regional personal income, number of doctors available at medical institutions (per 1000 people), financial autonomy ratio, rate of participation in volunteer activities, and single-person household ratio [11,17,18].

Statistical Analysis

To examine the association of socioeconomic factors to depression and quality of life in patients with hypertension, a weighted frequency analysis was conducted with individual and household weights applied to individual variables, and simple frequency analysis was conducted for regional variables. For the multilevel analysis of regional variables, 5 regional variables were added to increase the rigor of the research model. This was based on the fact that the average number of regional variables was 4.64 in a paper that systematically reviewed 128 documents using multilevel analysis in the healthcare field, and that if more regional variables than necessary were used, results might be distorted due to multicollinearity between variables. As an alternative to identifying multicollinearity problems between variables, we conducted Spearman correlation analysis for continuous variables. The correlation coefficient between the rate of participation in volunteer activities and the ratio of single-person households was the highest at 0.654. Thus, it was judged that the correlation coefficient between variables was not too high for a multilevel analysis. Using basic statistics from the regional factors, it was found that there were statistically significant differences in depression and quality of life for both the individual and regional factors of patients with hypertension. A multilevel analysis, which can consider the characteristics of individual-level and regional-level at the same time, consists of (1) a basic model, (2) a model containing only individual variables, and (3) a model containing both individual and regional variables. Intraclass correlation coefficients (ICCs) were analyzed to determine whether the research model was suitable for multilevel analysis. The ICC is an indicator of inter-regional heterogeneity or intra-regional homogeneity. It represents the proportion of regional variance to the total variance of dependent variables, which can also be understood as the variance explained by inter-regional differences [19]. A larger ICC suggests a higher explanatory power of

individual and regional characteristics affecting the dependent variable [20]. Using the GLIMMIX procedure of the statistical program SAS version 9.4 (SAS Institute Inc., Cary, NC, USA), a multilevel logistic regression analysis that could simultaneously consider individual and regional characteristics was performed.

$$ICC = \frac{\tau}{(\tau + \sigma^2)}$$

The independent variables included dietary conditions, gross regional personal income, the number of doctors available at medical institutions, and the rates of participation in volunteer activities, which were significantly correlated with depression, while gender and employment levels were significantly correlated with quality of life. Simple linear regression analysis was used to compare patients with hypertension to those without hypertension.

Ethics Statement

The Office of Research Integrity and Compliance Institutional Review Board at the Kangwon National University exempted the inspection of this study.

RESULTS

Prevalence of Depression and Quality of Life by Socioeconomic Status in Patients With Hypertension

To examine whether there were differences in the prevalence of depression and in quality of life according to the socioeconomic factors of patients with hypertension, a weighted frequency analysis was conducted with weights applied to individual socioeconomic factors. Simple frequency analysis was conducted without weights for regional variables (Table 1). Overall, the prevalence was higher in patients with hypertension than in patients without hypertension. The prevalence of depression was higher, and the quality of life was lower for those with lower education-levels, an employment status corresponding to non-economic activity, poor dietary conditions, and for those who received livelihood benefits.

Association of Socioeconomic Status With Depression in the Multilevel Analysis

The results of the multilevel analysis to identify the association between SES and depression are presented in Table 2. In model 1, the associations of individual variables with depres-

Table 1. Prevalence of depression and quality of life by socioeconomic status in patients with hypertension

Variables	Depression				Quality of life			
	Hypertension				Hypertension			
	Yes	%	No	%	Yes	%	No	%
Individual-level								
Gender								
Men	28 955 (1523)	5.3	73 569 (2939)	4.0	28 958 (8100)	28.0	73 563 (10 812)	14.7
Women	36 607 (3217)	8.8	89 826 (6383)	7.1	36 610 (19 093)	52.1	89 833 (21 775)	24.2
Age (y)								
19-29	293 (33)	11.3	23 079 (1217)	5.3	293 (61)	20.8	23 078 (2617)	11.3
30-39	967 (89)	9.2	25 740 (1421)	5.5	967 (146)	15.1	25 739 (3030)	11.8
40-49	3619 (246)	6.8	32 281 (1671)	5.2	3617 (573)	15.8	32 284 (3920)	12.1
50-59	10 686 (730)	6.8	33 476 (1881)	5.6	10 686 (2177)	20.4	33 471 (5388)	16.1
60-69	18 718 (1295)	6.9	26 209 (1569)	6.0	18 716 (5780)	30.9	26 215 (6195)	23.6
≥70	31 279 (2347)	7.5	22 610 (1563)	6.9	31 289 (18 456)	59.0	22 609 (11 437)	50.6
Education-level								
≥University	8804 (448)	5.1	61 242 (2802)	4.6	8804 (1559)	17.7	61 237 (7101)	11.6
High school	15 685 (1027)	6.5	59 702 (3315)	5.5	15 686 (3955)	25.2	59 706 (8810)	14.8
Middle school	10 307 (660)	6.4	15 186 (1078)	7.1	10 307 (3495)	33.9	15 190 (3885)	25.6
Primary school	17 387 (1323)	7.6	17 447 (1256)	7.2	17 386 (8643)	49.7	17 450 (6684)	38.3
No school	13 288 (1274)	9.6	9686 (864)	8.9	13 295 (9508)	71.5	9682 (6071)	62.7
Employment status[1]								
Professional administrative management position	2973 (156)	5.2	20 218 (968)	4.8	2973 (397)	13.3	20 217 (2164)	10.7
Office work	2102 (72)	3.4	17 589 (699)	4.0	2102 (244)	11.6	17 589 (1677)	9.5
Sales service position	5990 (354)	5.9	24 088 (1317)	5.5	5990 (1358)	22.7	24 089 (3408)	14.1
Agriculture, forestry and fisheries	10 033 (459)	4.6	15 312 (639)	4.2	10 032 (3785)	37.7	15 315 (3802)	24.8
Simple functional workers	12 071 (628)	5.2	30 788 (1389)	4.5	12 069 (3163)	26.2	30 787 (4444)	14.4
Others	32 318 (3063)	9.5	55 164 (4296)	7.8	32 328 (18 222)	56.4	55 164 (17 040)	30.9
Basic livelihood recipient status								
Non-recipient	61 518 (4056)	6.6	158 212 (8526)	5.4	61 519 (24 369)	39.6	158 215 (30 072)	19.0
Past recipient	563 (61)	10.8	918 (130)	14.2	563 (363)	64.5	920 (338)	36.7
Recipient	3422 (620)	18.1	4133 (660)	16.0	3427 (2436)	71.1	4128 (2149)	52.1
Dietary conditions								
Very good	35 635 (1799)	5.0	108 167 (5029)	4.6	35 635 (11 199)	31.4	108 173 (16 272)	15.0
Good	25 057 (2034)	8.1	49 031 (3340)	6.8	25 060 (12 605)	50.3	49 030 (13 263)	27.0
Insufficient	4018 (677)	16.8	5100 (713)	14.0	4022 (2769)	68.8	5098 (2466)	48.4
Very insufficient	769 (221)	28.7	939 (228)	24.3	768 (585)	76.2	937 (549)	58.6
Regional-level								
Gross regional personal income (10^4 Korean won)[2]								
≥4000	11 104 (791)	7.1	29 825 (1808)	6.1	11 108 (4718)	42.5	29 829 (6158)	20.6
3000-4000	39 049 (2751)	7.0	98 972 (5568)	5.6	39 055 (15 798)	40.4	98 960 (19 051)	19.2
<3000	15 409 (1198)	7.8	34 598 (1946)	5.6	15 405 (6677)	43.3	34 607 (7378)	21.3
No. of doctors available at medical institutions (per 1000 population)[3]								
≥2.5	34 054 (2411)	7.1	81 533 (4542)	5.6	34 059 (14 381)	42.2	81 542 (16 427)	20.1
<2.5	31 508 (2329)	7.4	81 862 (4780)	5.8	31 509 (12 812)	40.7	81 854 (16 160)	19.7

Table 1. Continued from the previous page

Variables	Depression				Quality of life			
	Hypertension				Hypertension			
	Yes	%	No	%	Yes	%	No	%
Financial autonomy ratio (%)[4]								
≥65	35 507 (2703)	7.6	95 061 (5770)	6.1	35 510 (14 036)	39.5	95 059 (18 493)	19.4
<65	30 055 (2037)	6.8	68 334 (3552)	5.2	30 058 (13 157)	43.8	68 337 (14 094)	20.6
Rate of participation in volunteer activities (%)[5]								
≥20	180 (7)	3.9	735 (38)	5.2	179 (56)	31.3	736 (87)	11.8
<20	65 382 (4733)	7.2	162 660 (9284)	5.7	65 389 (27 137)	41.5	162 660 (32 500)	20.0
Single-person household ratio (%)[6]								
≥33	13 661 (888)	6.5	28 884 (1522)	5.3	13 662 (5717)	41.8	28 881 (5946)	20.6
30-33	31 871 (2304)	7.2	73 942 (4264)	5.8	31 876 (13 980)	43.9	73 949 (15 580)	21.1
<30	20 030 (1548)	7.7	60 569 (3536)	5.8	20 030 (7496)	37.4	60 566 (11 061)	18.3

Values are presented as case (depression case).
[1]Others include soldiers, students, housewives, and unemployed.
[2]Gross regional personal income received from outside the region in gross regional product, and the principal income paid outside the region, is deducted; Therefore, the gross regional income is larger than gross regional product when net income flows from outside the region, and it is smaller than gross regional product when net income flows outside the region.
[3]Refers to the total number of physicians (physicians, oriental doctors, dentists) employed at medical institutions per 1000 people, as stipulated in Article 3 of the Medical Service Act.
[4]Ratio of local tax and non-tax income in the revenue of general accounts: a revenue analysis indicator that shows the ability to independently obtain fiscal revenue, in which a higher financial independence indicates excellent self-reliance in financial management.
[5]Percentage of adult volunteers who have registered on the 1365 Volunteer Portal and participated in volunteer activities at least once compared to the total number of adults.
[6]The proportion of the units of living in which one person makes a living alone.

sion were examined. The analysis showed that women, those with lower levels of education, benefit recipients, and those with poor dietary conditions had the highest depression scores. In model 2, the associations of both individual variables and regional variables with depression were analyzed. Regarding regional variables, lower gross regional personal income, a lower number of doctors available at medical institutions, and lower rates of participation in volunteer activities were significantly associated with higher levels of depression. Overall, dietary conditions, gross regional personal income, the number of doctors available at medical institutions, and the rate of participation in volunteer activities showed stronger associations with depression in patients with hypertension than in patients without hypertension.

Association of Socioeconomic Status With Quality of Life in the Multilevel Analysis

The results of the multilevel analysis to determine the association between SES and quality of life are presented in Table 2. In model 1, the associations of all individual variables with diminished quality of life were examined. The results of our analysis showed that women, those with lower levels of edu-

cation, benefit recipients, and those with poor dietary conditions had the highest reductions in quality of life. In model 2, the associations of both individual variables and regional variables with reduced quality of life were analyzed. Regarding regional variables, those with lower gross regional personal income, a lower number of doctors available at medical institutions, and lower rates of participation in volunteer activities were associated with the highest reductions in quality of life, although the decline was not statistically significant. Overall, gender and employment status showed stronger associations with quality of life in patients with hypertension than in patients without hypertension.

Interrelationships of Hypertension With Depression and Quality of Life

Table 3 shows the results of univariate logistic regression analysis to confirm the correlations of hypertension with SES, depression, and quality of life. The results revealed that the risk of depression was significantly higher in patients with hypertension with poor dietary conditions, those with lower gross regional personal income, a lower number of doctors available at medical institutions, and a lower rate of participa-

Table 2. Multilevel analysis of socioeconomic status affecting depression in patients with and without hypertension

Variables	Depression						Quality of life					
	Hypertension						Hypertension					
	Yes			No			Yes			No		
	Null model	Model 1	Model 2	Null model	Model 1	Model 2	Null model	Model 1	Model 2	Null model	Model 1	Model 2
Individual-level												
Gender												
Men		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
Women		1.47 (1.36, 1.57)	1.47 (1.37, 1.58)		1.66 (1.58, 1.74)	1.66 (1.58, 1.74)		1.69 (1.62, 1.76)	1.69 (1.62, 1.76)		1.62 (1.57, 1.67)	1.62 (1.58, 1.67)
Age (y)												
19-29		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
30-39		1.01 (0.65, 1.55)	1.01 (0.65, 1.55)		1.22 (1.12, 1.32)	1.22 (1.12, 1.32)		0.87 (0.62, 1.24)	0.87 (0.62, 1.24)		1.24 (1.17, 1.31)	1.24 (1.17, 1.31)
40-49		0.63 (0.42, 0.93)	0.63 (0.42, 0.93)		1.08 (1.00, 1.17)	1.08 (1.00, 1.17)		0.78 (0.57, 1.06)	0.78 (0.57, 1.06)		1.25 (1.18, 1.32)	1.25 (1.18, 1.32)
50-59		0.54 (0.37, 0.79)	0.54 (0.37, 0.78)		1.02 (0.95, 1.11)	1.02 (0.95, 1.11)		0.79 (0.59, 1.06)	0.79 (0.59, 1.06)		1.45 (1.38, 1.53)	1.45 (1.38, 1.53)
60-69		0.44 (0.30, 0.64)	0.44 (0.30, 0.64)		0.90 (0.82, 0.98)	0.90 (0.82, 0.98)		0.91 (0.68, 1.23)	0.91 (0.68, 1.23)		1.65 (1.56, 1.74)	1.65 (1.56, 1.74)
≥70		0.34 (0.23, 0.50)	0.34 (0.23, 0.50)		0.80 (0.72, 0.88)	0.80 (0.72, 0.88)		1.75 (1.30, 2.36)	1.75 (1.30, 2.36)		3.46 (3.26, 3.68)	3.46 (3.26, 3.68)
Education-level												
≥University		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
High school		1.17 (1.03, 1.32)	1.16 (1.03, 1.32)		1.19 (1.12, 1.26)	1.19 (1.12, 1.26)		1.24 (1.15, 1.33)	1.24 (1.15, 1.33)		1.11 (1.06, 1.15)	1.11 (1.06, 1.15)
Middle school		1.13 (0.98, 1.30)	1.13 (0.98, 1.30)		1.62 (1.48, 1.77)	1.62 (1.48, 1.77)		1.45 (1.34, 1.57)	1.45 (1.34, 1.57)		1.58 (1.50, 1.67)	1.58 (1.50, 1.67)
Primary school		1.28 (1.12, 1.47)	1.28 (1.11, 1.46)		1.62 (1.48, 1.79)	1.62 (1.48, 1.79)		2.07 (1.92, 2.24)	2.07 (1.92, 2.23)		2.14 (2.03, 2.26)	2.14 (2.03, 2.26)
No school		1.42 (1.23, 1.64)	1.42 (1.22, 1.64)		1.72 (1.53, 1.93)	1.72 (1.53, 1.93)		3.42 (3.15, 3.72)	3.42 (3.14, 3.72)		3.71 (3.47, 3.97)	3.71 (3.47, 3.97)
Employment status												
Professional administrative management position		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
Office work		0.62 (0.46, 0.82)	0.62 (0.46, 0.82)		0.80 (0.73, 0.89)	0.80 (0.73, 0.89)		0.94 (0.79, 1.11)	0.94 (0.79, 1.11)		0.91 (0.85, 0.97)	0.91 (0.85, 0.97)
Sales service position		0.94 (0.77, 1.16)	0.94 (0.77, 1.16)		0.96 (0.88, 1.05)	0.96 (0.88, 1.05)		1.03 (0.91, 1.18)	1.03 (0.91, 1.18)		1.01 (0.95, 1.07)	1.01 (0.95, 1.07)
Agriculture, forestry, and fisheries		0.86 (0.70, 1.05)	0.86 (0.70, 1.05)		0.76 (0.67, 0.85)	0.76 (0.67, 0.85)		1.25 (1.10, 1.42)	1.25 (1.10, 1.42)		1.02 (0.95, 1.09)	1.02 (0.95, 1.09)
Simple functional workers		0.86 (0.71, 1.04)	0.86 (0.71, 1.04)		0.84 (0.77, 0.92)	0.84 (0.77, 0.92)		0.97 (0.85, 1.09)	0.97 (0.85, 1.09)		0.89 (0.84, 0.95)	0.89 (0.84, 0.95)
Others[1]		1.47 (1.22, 1.77)	1.47 (1.22, 1.77)		1.22 (1.12, 1.32)	1.22 (1.12, 1.32)		2.18 (1.94, 2.46)	2.18 (1.94, 2.46)		1.61 (1.52, 1.69)	1.61 (1.52, 1.69)
Basic livelihood recipient status												
Non-recipient		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
Past recipient		1.20 (0.91, 1.58)	1.20 (0.91, 1.59)		2.12 (1.75, 2.57)	2.12 (1.75, 2.57)		1.54 (1.27, 1.88)	1.54 (1.27, 1.88)		1.52 (1.30, 1.77)	1.52 (1.30, 1.78)
Recipient		1.66 (1.49, 1.84)	1.65 (1.49, 1.83)		1.82 (1.65, 2.00)	1.82 (1.65, 2.01)		1.86 (1.70, 2.02)	1.86 (1.70, 2.03)		2.12 (1.97, 2.28)	2.12 (1.97, 2.28)
Dietary conditions												
Very good		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)		1.00 (reference)	1.00 (reference)
Good		1.57 (1.46, 1.68)	1.57 (1.46, 1.68)		1.40 (1.33, 1.47)	1.40 (1.33, 1.47)		1.59 (1.53, 1.65)	1.59 (1.53, 1.65)		1.53 (1.49, 1.58)	1.53 (1.49, 1.58)
Insufficient		2.96 (2.66, 3.28)	2.96 (2.67, 3.29)		2.52 (2.30, 2.77)	2.53 (2.30, 2.77)		2.54 (2.34, 2.75)	2.54 (2.34, 2.75)		2.57 (2.40, 2.75)	2.57 (2.40, 2.75)
Very insufficient		5.32 (4.47, 6.33)	5.34 (4.48, 6.35)		4.37 (3.71, 5.15)	4.38 (3.71, 5.16)		3.40 (2.83, 4.09)	3.40 (2.83, 4.09)		3.53 (3.04, 4.11)	3.53 (3.04, 4.11)

Table 2. Continued from the previous page

Variables	Depression						Quality of life					
	Hypertension Yes			Hypertension No			Hypertension Yes			Hypertension No		
	Null model	Model 1	Model 2	Null model	Model 1	Model 2	Null model	Model 1	Model 2	Null model	Model 1	Model 2
Regional-level												
Gross regional person income (10⁴ Korean won)												
≥4000		-	1.00 (reference)		-	1.00 (reference)			1.00 (reference)			1.00 (reference)
3000-4000		-	1.13 (0.91, 1.40)		-	1.05 (0.83, 1.33)			0.92 (0.73, 1.16)			0.97 (0.73, 1.27)
<3000		-	1.48 (1.11, 1.96)		-	1.17 (0.85, 1.62)			1.12 (0.82, 1.52)			1.18 (0.81, 1.70)
No. of doctors available at medical institutions (per 1000 population)												
≥2.5		-	1.00 (reference)		-	1.00 (reference)			1.00 (reference)			1.00 (reference)
<2.5		-	1.21 (1.02, 1.44)		-	1.12 (0.92, 1.36)			1.10 (0.92, 1.33)			1.12 (0.89, 1.40)
Financial independence (%)												
≥65		-	1.00 (reference)		-	1.00 (reference)			1.00 (reference)			1.00 (reference)
<65		-	0.78 (0.66, 0.92)		-	0.80 (0.66, 0.96)			0.93 (0.78, 1.11)			0.83 (0.67, 1.03)
Rate of participation in volunteer activities (%)												
≥20		-	1.00 (reference)		-	1.00 (reference)			1.00 (reference)			1.00 (reference)
<20		-	1.99 (0.88, 4.52)		-	1.17 (0.71, 1.91)			1.31 (0.79, 2.18)			1.75 (1.06, 2.88)
Single-person household ratio (%)												
≥33		-	1.00 (reference)		-	1.00 (reference)			1.00 (reference)			1.00 (reference)
30-33		-	1.22 (0.99, 1.49)		-	1.20 (0.96, 1.51)			1.12 (0.90, 1.39)			1.22 (0.94, 1.58)
<30		-	1.19 (0.97, 1.46)		-	1.14 (0.90, 1.44)			1.01 (0.81, 1.26)			1.15 (0.88, 1.50)
Between community variance (SE)	0.028 (0.012)	0.027 (0.012)	0.014 (0.009)	0.021 (0.008)	0.025 (0.010)	0.022 (0.011)	0.041 (0.016)	0.019 (0.008)	0.020 (0.011)	0.058 (0.022)	0.037 (0.014)	0.031 (0.016)
ICC (H_0: variance of random intercept=0)	0.008 (<0.001)	0.008 (<0.001)	0.004 (<0.001)	0.006 (<0.001)	0.007 (<0.001)	0.007 (<0.001)	0.012 (<0.001)	0.006 (<0.001)	0.006 (<0.001)	0.017 (<0.001)	0.011 (<0.001)	0.009 (<0.001)
Variation explained (%)	0.84	0.82	0.43	0.63	0.76	0.66	1.24	0.59	0.61	1.73	1.12	0.94

Values are presented as odds ratio (95% confidence interval).
SE, standard error; ICC, intraclass correlation coefficient.
¹Others include soldiers, students, housewives, and unemployed.

Table 3. Interrelationships of depression and quality of life in patients with hypertension

Socioeconomic status	Hyper-tension	Depression	Quality of life
Individual-level			
Gender			
Men	No	1.00 (reference)	1.00 (reference)
	Yes	1.33 (1.25, 1.42)	2.25 (2.18, 2.33)
Women	No	1.84 (1.76, 1.92)	1.86 (1.81, 1.91)
	Yes	2.32 (2.20, 2.44)	6.33 (6.15, 6.51)
Employment status			
Professional administrative management position	No	1.00 (reference)	1.00 (reference)
	Yes	1.10 (0.93, 1.31)	1.29 (1.15, 1.44)
Office work	No	0.82 (0.75, 0.91)	0.88 (0.82, 0.94)
	Yes	0.71 (0.55, 0.90)	1.10 (0.95, 1.26)
Sales service position	No	1.15 (1.06, 1.25)	1.38 (1.30, 1.46)
	Yes	1.25 (1.10, 1.42)	2.45 (2.27, 2.64)
Agriculture, forestry, and fisheries	No	0.87 (0.78, 0.96)	2.76 (2.60, 2.92)
	Yes	0.95 (0.85, 1.07)	5.06 (4.76, 5.37)
Simple functional workers	No	0.94 (0.86, 1.02)	1.41 (1.33, 1.49)
	Yes	1.09 (0.99, 1.21)	2.96 (2.79, 3.15)
Others[1]	No	1.68 (1.56, 1.80)	3.73 (3.55, 3.91)
	Yes	2.08 (1.93, 2.24)	10.78 (10.25, 11.33)
Dietary conditions			
Very good	No	1.00 (reference)	1.00 (reference)
	Yes	1.09 (1.03, 1.15)	2.59 (2.52, 2.66)
Good	No	1.50 (1.43, 1.57)	2.09 (2.04, 2.15)
	Yes	1.81 (1.72, 1.91)	5.72 (5.55, 5.89)
Insufficient	No	3.33 (3.06, 3.63)	5.29 (5.00, 5.60)
	Yes	4.16 (3.81, 4.54)	12.48 (11.65, 13.37)
Very insufficient	No	6.58 (5.65, 7.66)	7.99 (7.01, 9.11)
	Yes	8.27 (7.06, 9.69)	18.05 (15.28, 21.33)
Regional-level			
Gross regional person income (10^4 Korean won)			
≥4000	No	1.00 (reference)	1.00 (reference)
	Yes	1.19 (1.09, 1.30)	2.84 (2.71, 2.97)
3000-4000	No	0.92 (0.88, 0.98)	0.92 (0.89, 0.95)
	Yes	1.17 (1.11, 1.25)	2.61 (2.52, 2.70)
<3000	No	0.92 (0.87, 0.99)	1.04 (1.00, 1.08)
	Yes	1.31 (1.21, 1.41)	2.94 (2.82, 3.07)
No. of doctors available at medical institutions (per 1000 population)			
≥2.5	No	1.00 (reference)	1.00 (reference)
	Yes	1.29 (1.23, 1.36)	2.90 (2.82, 2.98)
<2.5	No	1.05 (1.01, 1.10)	0.98 (0.95, 1.00)
	Yes	1.35 (1.29, 1.43)	2.72 (2.64, 2.79)

(*Continued to the next*)

Table 3. Continued

Socioeconomic status	Hyper-tension	Depression	Quality of life
Rate of participation in volunteer activities (%)			
≥20	No	1.00 (reference)	1.00 (reference)
	Yes	0.74 (0.33, 1.69)	3.40 (2.31, 5.00)
<20	No	1.11 (0.80, 1.54)	1.86 (1.49, 2.33)
	Yes	1.43 (1.03, 1.99)	5.29 (4.23, 6.62)

Values are presented as odds ratio (95% confidence interval).
[1]Others include soldiers, students, housewives, and unemployed.

tion in volunteer activities. In other words, depression was closely related to SES and underlying diseases such as hypertension. Furthermore, the risk of deterioration in quality of life was significantly higher in patients with hypertension who were women and those with non-economic activities compared to groups without hypertension. In other words, quality of life was closely related to SES and the presence of underlying diseases, such as hypertension.

DISCUSSION

In this study, the associations of SES at the individual and regional levels with depression and quality of life for patients with hypertension aged 19 years and over were investigated. The presence of interconnected relationships among depression, quality of life, SES, and hypertension was confirmed.

The regional variable basic model (null model) was used to estimate the ICC, as a measure of the ratio of variance at each regional-level to the total variance with respect to depression and quality of life, and it was confirmed that there was an interregional variation of 0.84% for depression and 1.24% for quality of life. The fit of the model was found to be significant, rejecting the hypothesis that the variance of the random intercept was zero.

The ICCs for individual variance and regional variance in the association with depression were 0.82% and 0.43%, respectively, and 0.59% and 0.61% respectively, in the association with quality of life. In general, social science studies consider an ICC value >5% to be a significant difference [21]. However, researchers believe that multilevel analysis is possible despite a low ICC [20]. In this study, a low explanatory power was found for individual and regional variables in patients with hypertension with respect to depression and quality of life. Despite these limitations, this study suggests that there are significant variables at the individual-level and regional-level for patients with

hypertension based on the results of the multilevel analysis. Other studies have also reported that individual and regional variables in patients with hypertension were associated with depression and quality of life.

Previous studies on the association of patients' depression and quality of life with hypertension have shown that patients with hypertension have twice the risk of developing depression [22]. Physical functions, including the daily activities of patients with hypertension, have been found to be highly related to the health-related quality of life [23-25]. According to a study on depression in patients with hypertension, a high quality diet was a protective factor for depression in patients with hypertension [26]. Unhealthy lifestyle habits such as poor quality diets were risk factors for both depression and hypertension [16], indicating that poor dietary conditions are related to higher degrees of depression in patients with hypertension. Local income inequality has also been shown to affect depression [17], and volunteer activities is associated with hypertension [27], and participation in volunteer activities has been confirmed to alleviate depression [18]. The present study also found a higher risk of depression among patients with hypertension who reported poor dietary conditions, low gross regional personal incomes, and low rates of participation in volunteer activities. According to a Swedish study on the quality of life in patients with hypertension, men had a higher quality of life than women [28]. In addition, those with high-status jobs [10] had a higher health-related quality of life. The present study also found lower quality of life for women patients with hypertension and those with a low employment status.

In our study, certain results were in conflict with the overall general results or were inconsistent with other research findings. Although it has been reported that, at the regional-level, a high number of doctors available at medical institutions is associated with high levels of depression in patients with hypertension [11], in this study, a low number of doctors available at medical institutions was associated with higher levels of depression. In addition, a study on the financial independence of patients with hypertension, found that lower financial independence was related to higher levels of depression [11]. However, in this study, lower financial independence was associated with lower levels of depression. The reason for this difference might be that depression and quality of life were subjectively evaluated by individuals, resulting in the answers being influenced by personal factors.

In terms of research methodology, Jeon et al. [29] conducted multiple logistic regression analysis to identify the factors related to depression in patients with hypertension, logistic regression analysis was used for the their domestic study of the effects of hypertension on depression [9], and multiple regression analysis was used to identify the factors affecting health-related quality of life in patients with hypertension [10]. Moon et al. [11] performed a multilevel analysis on the effect of depression, but did not focus on patients with hypertension.

While there are many individual-level studies on the association between patients with hypertension and depression or quality of life, few studies have conducted multilevel analysis at the regional-level, and further studies are needed. This study was based on the socioeconomic theory of community health determinants and the individual characteristics of depression and quality of life; therefore, it integrated and analyzed regional indicators as well as individual indicators. Both individual factors and regional factors were associated with depression and quality of life. An analysis of the interrelationship of hypertension with depression and quality of life confirmed that depression and quality of life were closely related to SES and underlying diseases such as hypertension.

This study had some limitations. First, this study was based on data from a specific year; therefore, subsequent changes at the individual or local socioeconomic level and changes in hypertension levels were not considered. Because there was no Community Health Survey or questionnaire on the Quality-of-Life Index in 2020, only 2019 data were analyzed. Second, the gross regional personal income variable was not distinguished by level (city, county, and district levels). Therefore, to provide overall uniformity, the analysis was done based on city-level incomes. Third, regional-level factors associated with depression and quality of life were reflected in the study to an insufficient extent. Thus, follow-up studies that supplement these limitations should be conducted in the future.

Despite these limitations, this study considered the association of SES in patients with hypertension with depression and quality of life. Based on the inclusion and analysis of regional variables, this study suggests that the establishment of regional policies is necessary. Therefore, this study makes a significant contribution. Future studies, with additional indicators that better reflect regional characteristics could provide a more detailed evaluation and reflect individuals' period of residence in each city and province. In addition, attention at the

local level as well as the individual-level is necessary for disease mitigation in the future. Through this study, it was confirmed that poor dietary conditions, low personal gross income by region, and a low number of doctors available at medical institutions in women patients with hypertension were associated with higher levels of depression. In addition, it was confirmed that women gender and low employment status were associated with a lower quality of life among patients with hypertension. Policy interventions are needed to adjust health behavior factors, prevent depression, and improve quality of life. Therefore, a policy intervention study needs to be conducted in the future to address these factors that affect patients with hypertension.

CONFLICT OF INTEREST

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

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AUTHOR CONTRIBUTIONS

Both authors contributed equally to conceiving the study, analyzing the data, and writing this paper.

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