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ORIGINAL ARTICLE

Accuracy of Self-reported Hypertension, Diabetes, and Hypercholesterolemia: Analysis of a Representative Sample of Korean Older Adults

Heeran Chun [a], Il-Ho Kim [b,c,*], Kyung-Duk Min [d]

[a]*Department of Health Administration, Jungwon University, Chung-buk, Korea.*
[b]*Social and Epidemiological Research, Centre for Addiction and Mental Health, Toronto, Canada.*
[c]*Department of Psychiatry, University of Toronto, Toronto, Canada.*
[d]*Institute of Health and Environment, Graduate School of Public Health, Seoul National University, Seoul, Korea.*

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Abstract
Objectives: This study will assess the accuracy of self-reported hypertension, diabetes, and hypercholesterolemia among Korean older adults.
Methods: Using data from the fourth Korean National Health Examination and Nutrition Survey (KNHANES IV, 2007—2009), we selected 7,270 individuals aged 50 years and older who participated in both a health examination and a health interview survey. Self-reported prevalence of hypertension (HTN), diabetes mellitus (DM), and hypercholesterolemia was compared with measured data (arterial systolic/diastolic blood pressure, fasting glucose, and total cholesterol).
Results: An agreement between self-reported and measured data was only moderate for hypercholesterolemia (κ, 0.48), even though it was high for HTN (κ, 0.72) and DM (κ, 0. 82). Sensitivity was low in hypercholesterolemia (46.7%), but high in HTN and DM (73% and 79.3%, respectively). Multiple analysis shows that predictors for sensitivity differed by disease. People with less education were more likely to exhibit lower sensitivity to HTN and hypercholesterolemia, and people living in rural areas were less sensitive to DM and hypercholesterolemia.
Conclusion: Caution is needed in interpreting the results of community studies using self-reported data on chronic diseases, especially hypercholesterolemia, among adults aged 50 years and older.

1. Introduction

The accuracy of self-reported cardiovascular disease (CVD) and its determinant factors are a pivotal issue for global public health in CVD prevention and management among older populations. CVD continues to be a leading cause of morbidity and mortality in most developed and developing countries [1—3]. In accompaniment with a rapidly growing elderly population concomitant with increasing life expectancy, South Korea (hereafter Korea) has seen a dramatically increasing trend in the risk of CVD. The prevalence of

*Corresponding author.
E-mail: Il-Ho.Kim@camh.ca (I.-H. Kim).

CVD risk factors such as of hypertension (HTN), diabetes mellitus (DM), and hypercholesterolemia among adults (30 years or older) has increased from 24.6%, 9.6%, and 10.7% in 2007, to 27.3%, 11.0%, and 14.9%, in 2013, respectively [4]. To prevent and manage the increasing health burden of CVD risk factors, the Korean government implemented the National Cardio-Cerebrovascular Disease Plan 2010−2015 [5], but patients with these chronic diseases are frequently excluded from the government's enrollment system, due to limited public knowledge and awareness of CVD risk factors [6].

Accurately assessing the prevalence and trend of these diseases is a prerequisite for societal disease management and medication compliance. While, in reality, self-reported health data through surveys are widely used due to cost-effectiveness, it is noted that complex variations between subjective and objective measures of CVD risk factors hamper us from a better understanding of the magnitude of CVD, its associated factors, and the effectiveness of government interventions for its prevention [7−10]. A handful of studies suggest that the prevalence of self-reported DM shows a relatively high level of agreement [11−14], but high cholesterol revealed a significant discrepancy [9−11,15], with a mixed result for high blood pressure. A Minnesota study using 2,037 participants aged 45 years or older suggests that agreement between reported and medical records was noticeable for both DM and HTN (κ 0.71−0.80) [12]. In comparison to the American research, several European findings suggest similar agreement for DM (κ 0.84−0.76), but a significantly lower agreement for HTN (κ 0.63−0.51) and hypercholesterolemia (κ 0.55−0.48) [9,11,13]. A recent European study of 12 countries estimated that nearly 70% of European adults were unaware of having high cholesterol levels [11]. These results imply that undiagnosed cases of chronic patients could significantly deteriorate the quality of CVD primary care and intervention, when relying only on self-reported health data. However, there is a substantial knowledge gap in the accuracy of self-reported chronic diseases among Asian older adults. In addition, it is still unclear why this discrepancy in agreement exists for CVD risk factors, while emerging research shows that some sociodemographic factors such as age, sex, and education can contribute to its accuracy [9,16−19].

The central objective of this epidemiological research is to investigate the accuracy of self-reported HTN, DM, and hypercholesterolemia among Korean older adults. The specific goals of the study are to assess: (1) whether Korean older adults have a higher accuracy of reporting CVD risk factors when compared with measured data; (2) whether the extent to which the observed variation between the two measures differs in HTN, DM, and hypercholesterolemia; and (3) whether the extent may be attributable to demographic factors, socioeconomic factors, and/or health behavioral factors. The study will also examine whether there are different determinant factors between DM, HTN, and hyperlipidemia. To achieve our aims, we will use the Fourth Korean National Health and Nutritional Examination Survey (KNHANES IV), 2007−2009, the representative national data [20].

2. Materials and methods

2.1. Data and study population

This study is based on data from KNHANES, conducted from 2007 to 2009. This nationally representative cross-sectional survey included health interviews, health examinations, and nutritional surveys, intended to monitor the health and nutrition status of the Korean population. The details of this survey have been published in several publications [20]. Out of 24,871 individuals for whom both reported and measured data (health interviews and health examination) were available, 8,529 (34.3%) were over the age of 50 years. We obtained 7,270 observations for the final analysis, after eliminating all missing data.

2.2. CVD risk factors

CVD risk factors included HTN, DM, and hypercholesterolemia. Reported HTN, DM, and hypercholesterolemia cases were ascertained with the following questions. Has a doctor ever told you that you have: (1) high blood pressure or HTN? (2) hyperglycemia or DM? or (3) high blood cholesterol or hypercholesterolemia? Regarding the measured CVD risk factors, HTN was defined as a systolic blood pressure $\geq$ 140 mmHg, or diastolic blood pressure $\geq$ 90 mmHg, or currently using medication due to high blood pressure (Joint National Committee-6 definition) [21]. In the case of DM, individuals with fasting blood glucose levels of 126 mg/mL or those under treatment are categorized as DM [22]. Hypercholesterolemia is considered as a fasting blood cholesterol level $\geq$ 240 mg/mL or using medication for the condition [23].

2.3. Predictors

Sociodemographic and behavioral characteristics were taken into account as predictors of the discrepancy between reported and measured data. Sociodemographic variables included sex, marital status, region (urban/rural), education (elementary school/high school/college or higher), employment status (yes/no), and household income. The equalized household income levels were categorized into tertiles (high/middle/low), after household income was divided by the square root of the household size. This was to adjust for differences in disposable income by the numbers of people in the household [24].

We considered three behavioral factors: smoking (never/past/current); binge drinking (yes/no); and physical activity (yes/no). Binge drinking was defined as consuming alcohol more frequently than twice a week and more than seven glasses (50 mL; 5 glasses for women) on each occasion. Physical activity includes three types of exercise: (1) intensive activity for at least 20 minutes on 3 or more days a week; (2) moderate activity for at least 20 minutes on 5 days or more a week; and (3) walking for at least 30 minutes on 5 days or more a week. Self-rated health was divided into three groups: *very good and good*, *average*, and *poor and very poor*.

2.4. Statistical analysis

Descriptive statistics for proportions and mean were presented for all variables. Kappa statistics were employed to measure the accordance of reported and measured values. Sensitivity and specificity were calculated to examine the accuracy of reported HTN, DM, and hypercholesterolemia, compared with the gold standard measures of these CVD risk factors. We used multiple logistic regression models to assess factors associated with an individual's awareness of CVD risk factors. Awareness rates and sensitivity indicated the proportion of participants who reported having HTN, DM, and hypercholesterolemia among the cases of clinically measured CVD risk factors. SAS 9.3 was used for these statistical analyses.

3. Results

Table 1 shows the descriptive characteristics, the prevalence of CVD risk factors (HTN, DM, hypercholesterolemia), as well as the results of κ, sensitivity, and specificity tests between self-reported and measured diseases among participants aged 50 years or older. The first two columns of Table 1 show general characteristics of the study population. The sample consisted of similar proportions of three age groups: 50−59 years (36.8%), 60−69 years (34.7%), and 70 years and older (28.6%). The proportion of women was higher than men (57.4% vs 42.6%). Nearly three in four respondents were currently married, while one in four was divorced, separated, or widowed. The majority of participants (63.1%) lived in urban areas, compared to 37% rural dwellers. While the highest percentage of respondents (56.7%) had an education level of elementary school or less, only 9.1% of them had earned a college degree or higher, and 17.1% had received a high school diploma. About half of the respondents were in paid employment. In terms of health behaviors, 16.6% were current smokers, 22.6% were past smokers. About 7.8% were binge drinkers, and 41.3% did not exercise. More than one third of participants reported their health was very good or good, and another third reported having poor or very poor health.

The results in the right column show the prevalence and values of κ sensitivity and specificity between measured and self-reported HTN, DM, and hypercholesterolemia. The prevalence of three measured CVD risk factors was higher than that of reported risk factors, especially in reported hypercholesterolemia. In general, both the reported and measured prevalence in HTN and DM seems to be much higher among those who were older, previously married, and had lower socioeconomic status (lower education, lower income, not employed). For hypercholesterolemia, the reported and measured prevalence shows a similar trend to those of HTN and DM, but the measured prevalence differs across sex (women: 21%, men: 10.9%), marital status (previously married: 20.0%, married: 15.6), district (urban: 18.4%, rural: 13.7%), and employment status (not employed: 19.4%, employed: 14%). It is noteworthy that these differences were much higher than those of HTN and DM.

Regarding the results of κ and sensitivity tests, whereas HTN and DM showed substantial agreement (κ: 0.72 and 0.82, sensitivity: 73.0 and 79.3, respectively), hypercholesterolemia showed moderate agreement (κ: 0.48, sensitivity: 46.7). When considering demographic and socioeconomic factors overall, higher kappa and sensitivity between measured and reported HTN was found in the following three demographics: the middle age group (60−69 years), women, and the unemployed group. However, the differences were not found in DM, except not employed. By contrast, the agreement and sensitivity of hypercholesterolemia was higher among those with a higher level of education (κ: 0.54 vs. 0.46, sensitivity: 57.4 vs. 41.6) and a higher income (κ: 0.49 vs. 0.44, sensitivity: 52.1 vs. 39.8), compared with reference groups. Interestingly, the κ and specificity in hypercholesterolemia were higher among those who were non-employed than employed, in all three CVD risk factors.

For health behavioral factors and self-rated health, the prevalence of measured HTN and DM was highest among past smokers (51.9% and 18.6%, respectively), binge drinkers (52.5% and 16.2%, respectively), and the no physical activity group (50.3% and 16.3%, respectively). By contrast, compared to the counterparts, the kappa and sensitivity in HTN and DM were higher among non-binge drinkers and never smoked. For hypercholesterolemia, measured prevalence was higher among never smoked and binge drinkers. The prevalence, κ, sensitivity in HTN, DM, and hypercholesterolemia were the highest among those who had *poor and very poor* self-rated health (κ: 0.77, 0.85, and 0.52; sensitivity: 80.6, 87.5, and 52.6, respectively). It is noteworthy that specificity for all three diseases shows a high accuracy of $> 95\%$, regardless of the individual's socioeconomic or health behavioral factors.

Table 2 shows the results of multiple logistic regressions, examining the sociodemographic and behavioral factors associated with the sensitivity of CVD risk

Table 1. Discrepancy between reported and measured hypertension, diabetes, and hypercholesterolemia and associated factors in Korean elderly, aged 50 years or more, Fourth Korean National Health Examination and Nutrition Survey 2007−2009.

		50+	Hypertension (%)					Diabetes (%)					Hypercholesterolemia (%)				
		n (%)	R	M	κ	Sensitivity	Specificity	R	M	κ	Sensitivity	Specificity	R	M	κ	Sensitivity	Specificity
Total		7,270 (100)	36.4	48.8	0.72	73.0	98.5	13.6	15.4	0.82	79.3	98.4	11.7	16.7	0.48	46.7	95.4
Age (y)	50−59	2,674 (36.8)	23.9	36.5	0.67	63.5	98.8	8.7	11.2	0.77	70.7	99.1	13.1	16.8	0.45	46.9	93.7
	60−69	2,519 (34.7)	40.5	51.5	0.76	77.5	98.9	17.5	18.3	0.84	85.0	97.6	14.2	18.6	0.53	53.1	94.7
	≤ 70	2,077 (28.6)	47.5	61.4	0.69	75.8	97.5	15.2	17.2	0.81	79.3	98.2	6.6	14.2	0.44	36.3	98.3
Sex	Male	3,096 (42.6)	34.4	48.9	0.67	68.3	98.1	14.9	17.0	0.81	78.9	98.2	9.2	10.9	0.47	48.5	95.5
	Female	4,174 (57.4)	37.9	48.7	0.76	76.5	98.8	12.7	14.2	0.82	79.8	98.5	13.4	21.0	0.48	46.0	95.2
Marital status	Married	5,426 (74.6)	33.7	45.8	0.71	71.6	98.4	13.4	15.3	0.81	78.7	98.5	11.8	15.6	0.48	48.7	95.0
	others	1,844 (25.4)	44.4	57.5	0.73	76.4	99.1	14.2	15.5	0.82	81.1	98.1	11.1	20.0	0.46	42.1	96.6
Region	Urban	4,584 (63.1)	36.4	48.7	0.73	73.6	98.9	14.6	16.3	0.82	80.8	98.3	13.6	18.4	0.50	50.3	94.7
	Rural areas	2,686 (37.0)	36.3	49.0	0.70	72.0	98.0	11.8	13.8	0.80	76.5	98.5	8.4	13.7	0.42	38.5	96.4
Education	≥ College	675 (9.3)	31.0	40.7	0.75	73.8	98.5	10.8	12.2	0.79	76.8	98.3	15.0	17.0	0.54	57.4	93.8
	High school	1,279 (17.6)	33.9	46.1	0.71	71.5	98.4	12.1	14.7	0.82	77.1	99.1	15.5	16.3	0.49	55.8	92.3
	Middle school	1,194 (16.4)	30.7	42.1	0.73	71.6	99.0	13.2	14.6	0.84	81.6	98.5	12.1	16.2	0.49	49.2	95.0
	≤ Elementary school	4,122 (56.7)	39.7	52.9	0.71	73.7	98.4	14.6	16.4	0.81	79.7	98.1	9.8	16.9	0.46	41.6	96.7
Employment	Yes	3,643 (50.1)	30.3	43.8	0.68	67.5	98.6	10.8	12.6	0.79	75.8	98.6	9.9	14.0	0.44	43.1	95.5
	No	3,627 (49.9)	42.5	53.8	0.75	77.6	98.4	16.4	18.2	0.83	81.8	98.2	13.4	19.4	0.50	49.3	95.2
Income	High	2,370 (32.6)	31.2	43.8	0.72	70.4	99.3	10.6	12.7	0.79	75.1	98.7	14.1	17.1	0.49	52.1	93.8
	Middle	2,581 (35.5)	36.0	47.7	0.73	73.8	98.4	14.2	16.3	0.83	80.3	98.7	12.1	17.8	0.49	47.2	95.5
	Low	2,319 (31.9)	42.1	55.1	0.70	74.4	97.6	16.0	17.1	0.81	81.6	97.6	8.7	15.1	0.44	39.8	96.9
Smoking	Never smoker	4,441 (61.1)	37.4	48.9	0.75	75.3	98.9	12.8	14.5	0.82	80.1	98.5	13.2	19.2	0.49	48.3	95.2
	Past smoker	1,622 (22.3)	38.4	51.9	0.68	71.5	97.3	16.5	18.6	0.83	81.1	98.3	10.4	12.8	0.46	46.9	95.0
	Current smoker	1,207 (16.6)	30.1	44.3	0.67	66.2	98.7	12.5	14.5	0.76	73.7	97.9	7.9	12.9	0.41	37.8	96.6
Binge drinking	No	6,702 (92.2)	36.5	48.5	0.73	74.0	98.7	13.6	15.3	0.82	79.9	98.4	11.7	17.0	0.48	46.7	95.5
	Yes	568 (7.8)	34.5	52.5	0.58	62.4	96.3	13.2	16.2	0.77	72.8	98.3	11.1	13.2	0.44	46.7	94.3
Physical activity	Yes	4,267 (58.7)	35.3	47.8	0.72	72.4	98.6	13.3	14.8	0.81	79.5	98.2	11.4	16.1	0.48	47.0	95.5
	No	3,003 (41.3)	37.9	50.3	0.72	73.9	98.5	14.1	16.3	0.82	79.1	98.6	12.1	17.5	0.47	46.4	95.2
Self-rated health	Very good/good	2,584 (35.5)	30.5	45.1	0.67	66.3	98.9	8.5	11.3	0.77	69.8	99.3	9.8	15.8	0.43	40.3	96.0
	Average	2,148 (29.6)	33.3	46.3	0.70	70.3	98.6	11.4	13.6	0.78	74.0	98.4	11.4	16.3	0.48	46.4	95.4
	Poor/very poor	2,538 (34.9)	45.0	54.7	0.77	80.6	98.0	20.7	21.1	0.85	87.5	97.2	13.8	18.0	0.52	52.6	94.8

M = measured; R = reported.

Table 2. Results from multivariate logistic analysis* of sensitivity.

		Hypertension				Diabetes				Hypercholesterolemia			
		n = 3,547	(%)	OR	95% CI	n = 1,118	(%)	OR	95% CI	n = 1,214	(%)	OR	95% CI
Age (y)	50−59	975	27.5	Ref	—	300	26.8	Ref	—	450	37.1	Ref	—
	60−69	1,297	36.6	1.92	1.57−2.35	460	31.1	2.30	1.56−3.39	469	38.6	1.45	1.09−1.94
	≤ 70	1,275	36.0	1.65	1.31−2.08	358	32.0	1.47	0.95−2.28	295	24.3	0.82	0.57−1.19
Sex	Male	1,515	42.7	Ref	—	525	47.0	Ref	—	336	27.7	Ref	—
	Female	2,032	57.3	1.37	1.07−1.74	593	53.0	0.74	0.46−1.19	878	72.3	0.60	0.39−0.93
Marital status	Married	2,486	70.1	Ref	—	832	74.4	Ref	—	846	69.7	Ref	—
	others	1,061	29.9	0.99	0.82−1.21	286	25.6	1.11	0.75−1.64	368	30.3	0.95	0.71−1.27
Region	Urban	2,231	62.9	Ref	—	748	66.9	Ref	—	845	69.6	Ref	—
	Rural areas	1,316	37.1	0.93	0.78−1.10	370	33.1	0.70	0.50−0.99	369	30.4	0.71	0.54−0.93
Education	≥ College	275	7.8	Ref	—	82	7.3	Ref	—	115	9.5	Ref	—
	High school	590	16.6	0.78	0.56−1.09	188	16.8	0.86	0.45−1.64	208	17.1	0.93	0.58−1.50
	Middle school	503	14.2	0.69	0.49−0.98	174	15.6	1.01	0.51−1.99	193	15.9	0.71	0.43−1.17
	≤ Elementary school	2,179	61.4	0.57	0.41−0.79	674	60.3	0.76	0.40−1.43	698	57.5	0.55	0.35−0.88
Employment	Yes	1,595	45.0	Ref	—	459	41.1	Ref	—	510	42.0	Ref	—
	No	1,952	55.0	1.29	1.08−1.53	659	58.9	1.04	0.73−1.47	704	58.0	1.28	0.98−1.67
Income	High	1,038	29.3	Ref	—	301	26.9	Ref	—	405	33.4	Ref	—
	Middle	1,231	34.7	1.10	0.90−1.34	421	37.7	1.30	0.88−1.91	460	37.9	0.89	0.66−1.19
	Low	1,278	36.0	0.97	0.78−1.20	396	35.4	1.26	0.82−1.93	349	28.8	0.71	0.51−1.00
Smoking	Never smoker	2,171	61.2	Ref	—	642	57.4	Ref	—	851	70.1	Ref	—
	Past smoker	841	23.7	1.03	0.81−1.31	301	26.9	0.89	0.56−1.42	207	17.1	0.60	0.38−0.93
	Current smoker	535	15.1	0.87	0.67−1.12	175	15.7	0.63	0.38−1.03	156	12.9	0.41	0.26−0.66
Binge drinking	No	3,249	91.6	Ref	—	1,026	91.8	Ref	—	1,139	93.8	Ref	—
	Yes	298	8.4	0.85	0.65−1.11	92	8.2	0.82	0.48−1.42	75	6.2	1.09	0.64−1.84
Physical activity	Yes	2,038	57.5	Ref	—	630	56.4	Ref	—	688	56.7	Ref	—
	No	1,509	42.5	0.97	0.83−1.14	488	43.7	0.92	0.68−1.26	526	43.3	0.99	0.78−1.26
Self-rated health	Very good/good	1,164	32.8	Ref	—	291	26.0	Ref	—	409	33.7	Ref	—
	Average	994	28.0	1.25	1.04−1.51	292	26.1	1.24	0.85−1.81	349	28.8	1.34	0.99−1.82
	Poor/very poor	1,389	39.2	2.07	1.71−2.50	535	47.9	3.23	2.21−4.72	456	37.6	2.09	1.55−2.80

*Multiple logistic analysis include all variables—demographic (age, sex, marital status, region), socioeconomic (education, employment status, income), health behaviors (smoking binge drinking, physical activity), and self-rated health. CI = confidence interval; OR = odds ratio; Ref = reference category.

factors, after eliminating participants who did not possess each chronic disease according to the health examination. The total samples used in this analysis were 3,547 for HTN, 1,118 for DM, and 1,214 for hypercholesterolemia. In general, compared to participants aged 50−59 years, those aged 60−69 years had a high level of sensitivity for all three CVD risk factors (HTN, DM, hypercholesterolemia), while only adults aged 70 years or more were more aware of their HTN symptoms. Women have greater sensitivity to HTN than men [odds ratio (OR): 1.37, 95% confidence interval (CI): 1.07−1.74], but men were more sensitive to hypercholesterolemia (OR: 0.60, 95% CI: 0.39−0.93). Marital status did not influence sensitivity to all three risk factors. Compared with adults living in urban areas, rural dwellers were less likely to be aware of CVD risk factors, especially DM and hypercholesterolemia. According to one's education level, a socioeconomic gradient was found in awareness of HTN and hypercholesterolemia, but not in DM. Compared to those with college education or higher, ORs for sensitivity progressively decreased with a lower educational level. Participants who were not employed seemed to be more aware of their HTN and hypercholesterolemia than those who were employed.

Regarding health behaviors, only smoking was related to sensitivity of hypercholesterolemia. Sensitivity in past and current smokers was lower than for those who have never smoked (OR and 95% CI for past smoker: 0.60: 0.38−0.93; current smoker: 0.41: 0.26−0.66). Regardless of CVD risk factors, *poor and very poor* self-rated health was significantly associated with a higher rate of sensitivity than *good and very good* self-rated health (OR and 95% CI for HTN: 2.07, 1.71−2.50; DM: 3.23, 2.21−4.72; and hypercholesterolemia: 2.09, 1.55−2.80).

4. Discussion

This study was conducted to determine the accuracy of self-reported HTN, DM, and hypercholesterolemia when compared with global gold standard of measured data: representative national data from KNHANES IV. Our study's findings show that sensitivity of self-reported data for HTN and DM among Korean older adults aged 50 years and older was relatively high (73.0% for HTN and 79.3% for DM), but that of hypercholesterolemia was low (46.7%). Specificity, by contrast, provided accurate results for all three diseases (> 95%). Reliability, based on κ agreement, showed similar results: $\kappa = 0.72$, 0.82, and 0.48 for HTN, DM, and hypercholesterolemia, respectively. Reliability and validity tests show that self-reported data are relatively good for HTN and DM, but reported hypercholesterolemia suggests a significant reporting error. In terms of accuracy of reported DM, our results highly agreed with previous studies from other regions, such as Europe and the USA, which show high level of accuracy. Moreover, our findings were similar to those from European research of the agreement between self-reported and measured data for HTN and hypercholesterolemia. A Dutch study [13] showed the highest concordance for DM ($\kappa = 0.84$), a moderate level for HTN ($\kappa = 0.63$), and the lowest level for hypercholesterolemia ($\kappa = 0.48$). A study of the Spanish adult population [9] also suggested good agreement for self-reported DM ($\kappa = 0.78$), but moderate agreement for HTN ($\kappa = 0.51$), as well as poor agreement for hyperlipidemia ($\kappa = 0.27$). While respondents' awareness of the nature of their diseases can affect their accurate self-reporting, it is assumed that intervention programs for CVD risk factors—public education campaigns, knowledge translation, and the infrastructure of health examination programs across countries—may influence these differences in awareness of CVD risk factors.

Given the significance of preventing or controlling CVD risk factors, important modifiable risk factors in specificity for these diseases have not been adequately assessed. Our multiple logistic regression analysis shows that demographic and socioeconomic factors, behavioral factors, as well as self-rated health status are more likely to be significantly related to specificity in at least one of the three chronic diseases, but the direction of association differs according to the disease. Regarding chronological age, the elderly group aged 60−69 years turned out to have a higher awareness of all three diseases in comparison to adults aged 50−59 years and those aged 70 years or older, which proved inconsistent with previous studies [8,18,25]. Further analysis shows that those aged 60−69 years appear to have more medical check-ups; thus it is plausible that this age group seems to be more aware of the possibility of developing a chronic disease. When it comes to sex differences in awareness of diseases, our study shows that women are more vigilant for HTN, but negligent for hypercholesterolemia, which is in considerably disagreement with previous findings from other countries [18,21,25]. One of our study's notable findings was that, although females reported a greater prevalence of hypercholesterolemia, they were less aware of their symptoms than men. For all three diseases, rural people were less sensitive than urbanites, but about DM and hypercholesterolemia most especially. A possible explanation is that, when compared with urban elderly, rural dwellers may suffer from a scarcity of information, knowledge, or accessibility to health care services. Our further analysis (data not shown) reveals that the rural elderly may have difficulties interpreting the results of medical check-ups, even though the Korean government provides, free of charge, medical check-ups every 2 years for all Koreans over the age of 40 years, regardless of where they live.

While numerous studies have highlighted a socioeconomic gradient in health, our results also observed that highly educated groups were more sensitive to HTN and hypercholesterolemia. The socioeconomic gap in our study can be attributable to broader inequalities in socioeconomic forces; in particular, evidence shows that being highly educated is closely related to an increase in health-related information and knowledge, which lead to a higher awareness of chronic diseases [2,16,19,25]. Income levels are also known to be a relevant factor associated with higher awareness and better management [26], but our study found this link only for hypercholesterolemia. In contrast to previous findings [2], economically inactive groups in our study were more likely to be aware of HTN and hypercholesterolemia. It can be proposed that, more than likely they are spending more time on health management in comparison to the employed who have difficulty in balancing work with family life, for Koreans have the longest workweek of all OECD countries.

In contrast to other studies [17,27], health-related behavioral factors such as drinking and physical activities were not substantially associated with sensitivity for CVD risk factors. Only smoking influenced an awareness of CVD risk factors on health-related behaviors. In particular, hypercholesterolemia's sensitivity between reported and measured data was significantly lower among past and current smokers than among nonsmokers. In addition to these factors, our findings show that individuals with *average* and *poor* self-rated health had higher rate of agreement and of sensitivity for all three CVD risk factors, when compared with those with *good* self-rated health (e.g., OR in *poor* self-rated health: 2.07 for HTN, 3.23 for DM, and 2.09 for hypercholesterolemia). This result implies that self-rated health may be a useful indicator of awareness of CVD-related factors.

The limitations of this study are as follows. First, we cannot exclude the possibility of an over- or underdiagnosis of directly measured data. For example, in the case of white coat syndrome for HTN or DM, which is an anxiety-induced false positive reaction [25,28], the sensitivity level of self-reported data may be decreased. However, since our classification criteria for directly measured data did not cover all diagnosis criteria, except for fasting blood glucose levels, we also used the oral glucose tolerance test for DM diagnosis. Second, physician-related factors such as age or hospital setting were not controlled. The heterogeneity of disease criteria is limited to the results garnered from one country to another. Nevertheless, this study has strengths; it is based on a nationwide, largescale population, sampling scheme with a high response rate (74%), and the results of this study can be generalized to the Korean population as a whole. Moreover, this study's results provide diverse factors including sociodemographic and behavioral factors that influence awareness of CVD risk factors, which can use intervention programs of these diseases.

In conclusion, this study of Korean older adults reveals that reliability and validity of self-reported data for HTN and DM are generally acceptable, but for hypercholesterolemia is relatively poor. Caution is needed when interpreting the results of community studies using self-reported data on CVD risk factors, especially hypercholesterolemia, among adults aged 50 years and older. This result can be employed to find controllable risk factors for cardiovascular management that is specific to subgroups. In general, the elderly aged 60−69 years, who are highly educated, live in rural areas, are not engaged in the labor market, and have "poor" self-rated health are more likely to be aware of their three CVD risk factors. Compared to men, women are more likely to be vigilant of HTN, but less likely to be aware of hypercholesterolemia. *Past* and *current* smokers are particularly less sensitive for hypercholesterolemia. Our study's results imply the importance of health intervention programs and highlight the necessity for improving public knowledge and information. This requires further studies to elaborate more on the predictors of sensitivity and their strength of association. The results can also be used to find controllable risk factors specific to subgroups for cardiovascular management.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this paper.

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