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Research Article

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Factors associated with medication adherence among young adults with hypertension

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ABSTRACT

Background: Poor adherence to antihypertensive medication remains a significant barrier to blood pressure control in young patients. The objective of this study was to identify factors associated with antihypertensive medication adherence among young adults with hypertension.
Methods: From the Korean National Health Insurance Service database, we included 141,132 participants aged 20 to 39 years (80.4% male), without cardiovascular disease, who initiated antihypertensive medication between 2013 and 2018. Participants were categorized as exhibiting good adherence (proportion of days covered [PDC] ≥ 0.8) or poor adherence (PDC < 0.8) to antihypertensive medication during the first year of treatment. We investigated the associations of demographic, lifestyle, and clinical factors with good medication adherence based on logistic regression analysis.
Results: Only 43.3% (n = 61,107) of young adults with hypertension showed good adherence to antihypertensive medication. Male sex, older age, higher income, urban residence, non-smoking, and higher physical activity were associated with good medication adherence. Initial combination therapy, especially with single-pill combination (odds ratio [OR], 1.12; 95% confidence interval [CI], 1.07–1.18), was associated with good adherence. Among patients under monotherapy, initial use of renin-angiotensin blockers (OR, 5.24; 95% CI, 4.47–6.15) or calcium-channel blockers (OR, 4.07; 95% CI, 3.47–4.78) was associated with better adherence than initial diuretics.
Conclusions: Although antihypertensive medication adherence is generally poor among young adults, we identified potential demographic and clinical factors associated with good adherence to antihypertensive treatment. Initial use of a single-pill combination may promote adherence in young patients, and its long-term clinical outcomes warrant further investigation.

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Abbreviations

BMI, body mass index; CI, confidence interval; CVD, cardiovascular disease; HF, heart failure; ICD-10, International Classification of Diseases, 10th Revision; MI, myocardial infarction; NHIS, National Health Insurance Service; OR, odds ratio; PDC, proportion of days covered.

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Competing interest

The authors declare that they have no competing interests.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Ethics approval and consent to participate

The study protocol was approved by the Institutional Review Board of Yonsei University Health System, Seoul, Korea (approval Y-2021-0086). Informed consent was waived, because this is a retrospective study of deidentified, routinely collected data.

Consent for publication

Not applicable.

Authors' contributions

Conceptualization: Lee H, Cho SMJ; Data curation: Lee H, Kim HC; Formal analysis: Lee H, Lee HH, Kim EJ; Methodology: Lee H, Lee HH; Supervision: Lee H, Kim HC; Visualization: Kim E; Writing - origin al draft: Kim E; Writing - review & editing: Kim E, Lee HH, Kim EJ, Cho SMJ, Kim HC, Lee H.

Keywords: Medication adherence; Antihypertensive agents; Hypertension; Young adult; Drug combinations

BACKGROUND

Medication adherence is crucial to improving cardiovascular outcomes; approximately 47% of the significant decline in age-adjusted mortality for coronary heart disease in the United States between 1980 and 2000 was attributable to adherence to cardiovascular treatment [1]. However, promoting medication adherence remains challenging in clinical and public health settings [2,3]. While no official estimates exist regarding the prevalence of adherence to chronic illness medications, previous clinical trials have reported adherence rates ranging from 43% to 78% [2,4]. Poor medication adherence is particularly concerning for hypertension: nearly 50% of patients with hypertension discontinued antihypertensive medications within one year of treatment initiation, and less than 25% achieved controlled blood pressure [5-7]. Given that these estimates were derived from study participants who likely received more attention to taking medication, the adherence to antihypertensive medication may be even lower in real-world settings. Moreover, many studies reported that nonadherence to antihypertensives leads to higher cumulative exposure to high blood pressure, thereby at elevated risk for cardiovascular morbidity and mortality [8,9].

Young adults with hypertension have received less attention due to their low prevalence, despite having the lowest treatment and control rates among all age groups [10]. Improvements in hypertension management for young adults have remained stagnant for decades, with little progress observed [10]. However, previous studies on adherence to antihypertensive medication have mostly focused on older adults due to the higher prevalence of hypertension with advancing age [11-13]. Of the few studies focusing on young population, a nationwide study reported that young adults aged 20 to 44 years with poor antihypertensives adherence had a 1.6-fold higher risk for cardiovascular disease (CVD) events compared to individuals with good adherence [14]. A dose-response relationship was also observed between lower adherence and an increased risk of CVD [14]. Nevertheless, hypertension has been underrecognized in the young Korean population.

Taken together, poor adherence to antihypertensive medication poses a significant challenge to blood pressure control, but little is known about effective strategies to improve medication adherence in young patients. Therefore, this study aims to identify factors associated with antihypertensive medication adherence and persistence among young adults newly treated for hypertension.

METHODS

Data source

This study used the National Health Insurance Service (NHIS) database, which is built and managed by the single national health insurer in South Korea. The database contains policyholders' sociodemographic and clinical information, including hospital claims data with the International Classification of Diseases, 10th Revision (ICD-10) coding, mortality data, and health examination results [15]. The details for the NHIS database are elaborated elsewhere [14,16].

The study protocol was approved by the Institutional Review Board of Yonsei University Health System, Seoul, Korea (approval Y-2021-0086). Informed consent was waived, because this is a retrospective study of deidentified, routinely collected data.

Study participants

We identified young adults aged 20 to 39 years who initiated antihypertensive medication (claimed with an ICD-10: I10 diagnosis code and a relevant prescription) between January 1, 2013, and December 31, 2018, with no prior prescription of antihypertensives between 2002 and 2012. The index date was defined as the first date of antihypertensives initiation. Among 304,934 participants with no prescription history of antihypertensives before the index date and a total of ≥ 30 days' supply during 1 year after the index date, we excluded participants with incomplete information (n = 13,715), those with prior CVD (n = 18,176), and those who died or had a CVD event during the 1-year period after the index date (n = 1,434). These exclusions were made due to potential overlap between secondary CVD prevention and antihypertensive drugs, as well as the possibility of hard CVD events affecting drug prescriptions or introducing immeasurable time. Of the remaining 271,609, we analyzed 141,132 young patients who had completed the NHIS-provided health examinations within 4 years before the index date to collect lifestyle and metabolic risk factors (**Supplementary Fig. 1**).

Variables

Possible determinants of adherence were selected a priori based on previous literature suggesting potential correlations with medication adherence [17-19]. Sociodemographic factors including age, sex, household income, and urbanicity of residential areas were collected from the insurance eligibility data. Lifestyle, clinical, and laboratory measurements were extracted from the NHIS-provided health examination data closest to the index date within the past 4 years. Current smoking status, frequent alcohol drinking (drinking frequency ≥ 3 times/week), and physical inactivity (exercise frequency < 1 time/week) were self-reported. The number of metabolic risk factors was counted as the number of items that satisfied the following criteria: (1) fasting glucose ≥ 100 mg/dL or specific treatment; (2) triglycerides ≥ 150 mg/dL or specific treatment; (3) high-density lipoprotein cholesterol < 40 mg/dL in men or < 50 mg/dL in women or specific treatment; (4) waist circumference ≥ 90 cm in men or ≥ 85 cm in women. Therapy-related factors such as regimen (monotherapy or combination therapy), drug class (renin-angiotensin blockers, calcium channel blockers, beta-blockers, or diuretics), and the use of single-pill combinations were identified from claims data according to the methods developed for the Korea Hypertension Fact Sheets [20-23].

Outcomes

Medication adherence was determined by the proportion of days covered (PDC), which was calculated by dividing the number of days covered by a prescription refill by the total number of days in the observed time period (365 days) [14,24,25]. When there was an overlap in supply, or a change in drug class or dosage, the administration of any antihypertensive medication was counted only once per day. Medication adherence was categorized as "good" (PDC ≥ 0.8) or "poor" (PDC < 0.8) [11,14,24].

Medication persistence was determined by the last gap of coverage, which was defined as the number of days of medication discontinuation from the last day covered by medication to the last day of the observed time period [24,26,27] (**Supplementary Fig. 2**). If the medication was available through the end of the 1-year observation or beyond, the last gap

was considered 0 days. Medication persistence was categorized as "good" (last gap < 90 days) or "poor" (last gap ≥ 90 days) [24,27].

Statistical analyses

Baseline characteristics were presented as median with interquartile range or frequency with percentage according to medication adherence or persistence. The odds ratios (ORs) and 95% confidence intervals (CIs) associated with good medication adherence or persistence were calculated using multivariable logistic regression models. The independent variables included age, sex, household income, residential area, current smoking, frequent drinking, physical inactivity, the number of metabolic risk factors, and initial medication regimen. The analyses were conducted in the overall population and in subgroups of patients with initial monotherapy or initial combination therapy. Among initial monotherapy agents, diuretics were chosen as the reference based on previous literature indicating that diuretics were associated with the lowest adherence rate [28,29].

The following sensitivity analyses were performed. First, the observation period for medication adherence and persistence was extended from one year to 2 years—that is, PDC was calculated during 2 years from the index date; the last gap was the number of days of the most recent gap of medication discontinuation close to the last day of the 2-year observation. Second, the main analyses were repeated after including patients who did not take the NHIS-provided health examinations and thus were excluded from the study population. Analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, USA) and R version 4.0.3 (R Foundation for Statistical Computing, Vienna, Austria).

RESULTS

Baseline characteristics

The primary analysis included 141,132 young adults newly prescribed antihypertensives. Based on one-year observations, only 43.3% (n = 61,107) of participants showed good adherence to antihypertensive medication, while 65.6% (n = 92,645) were categorized as good persistence (**Supplementary Fig. 3**). Participants in the good adherence group were older, more likely to be male, had higher household income, resided more frequently in urban areas, and had a higher metabolic risk profile (**Table 1**). Renin-angiotensin blockers and calcium channel blockers were prescribed more frequently than other drug classes, with higher prescription rates in the good adherence group compared to the poor adherence group. Participants with good adherence were more likely to initiate antihypertensive therapy with combination pills, particularly single-pill combinations, than those with poor adherence. Meanwhile, participants with good persistence exhibited similar patterns to those in the good adherence group, except that the proportion of current smokers was higher among those with good persistence (**Table 1**).

Primary analyses

Table 2 presents the associations of sociodemographic, lifestyle, and clinical factors with medication adherence and persistence obtained from the multivariable logistic regression analysis. Older age (per 1 year; OR, 1.08 [95% CI, 1.08–1.09]) and male sex (vs. female, OR, 1.34 [95% CI, 1.30–1.38]) were associated with good adherence. In contrast, lower household income (vs. high, OR, 0.92 [95% CI, 0.89–0.95]), rural residence (vs. urban, OR, 0.91 [95% CI, 0.89–0.94]), current smoking (vs. non-smoking, OR, 0.76 [95% CI, 0.74–0.78]), frequent

Table 1. Baseline characteristics of study participants by adherence to antihypertensives

Characteristics	Total (*N* = 141,132)	Adherence		Persistence	
		Poor (*n* = 80,025)	Good (*n* = 61,107)	Poor (*n* = 48,487)	Good (*n* = 92,645)
Age (yr)	35 (32–38)	35 (32–37)	36 (33–38)	34 (31–37)	36 (33–38)
Sex					
Female	27,629 (19.6)	17,485 (21.8)	10,144 (16.6)	11,986 (24.7)	15,643 (16.9)
Male	113,503 (80.4)	62,540 (78.2)	50,963 (83.4)	36,501 (75.3)	77,002 (83.1)
Household income					
High	44,114 (31.3)	23,285 (29.1)	20,829 (34.1)	13,517 (27.9)	30,597 (33.0)
Middle	74,308 (52.7)	42,941 (53.7)	31,367 (51.3)	26,299 (54.2)	48,009 (51.8)
Low	22,710 (16.0)	13,799 (17.2)	8,911 (14.6)	8,671 (17.9)	14,039 (15.2)
Residential area					
Urban	116,960 (82.9)	65,832 (82.3)	51,128 (83.7)	39,817 (82.1)	77,143 (83.3)
Rural	24,172 (17.1)	14,193 (17.7)	9,979 (16.3)	8,670 (17.9)	15,502 (16.7)
Current smoking					
No	81,057 (57.4)	44,915 (56.1)	36,142 (59.1)	28,092 (57.9)	52,965 (57.2)
Yes	60,075 (42.6)	35,110 (43.9)	24,965 (40.9)	20,395 (42.1)	39,680 (42.8)
Frequent drinking (≥ 3/week)					
No	111,020 (78.7)	63,115 (78.9)	47,905 (78.4)	38,677 (79.8)	72,343 (78.1)
Yes	30,112 (21.3)	16,910 (21.1)	13,202 (21.6)	9,810 (20.2)	20,302 (21.9)
Physical inactivity (< 1/week)					
No	86,044 (61.0)	48,018 (60.0)	38,026 (62.2)	28,858 (59.5)	57,186 (61.7)
Yes	55,088 (39.0)	32,007 (40.0)	23,081 (37.8)	19,629 (40.5)	35,459 (38.3)
Obesity (BMI ≥ 25)					
No	44,387 (31.5)	27,512 (34.4)	16,875 (27.6)	18,697 (38.6)	25,690 (27.7)
Yes	96,745 (68.5)	52,513 (65.6)	44,232 (72.4)	29,790 (61.4)	66,955 (72.3)
Diabetes mellitus					
No	123,852 (87.8)	70,972 (88.7)	52,880 (86.5)	43,764 (90.3)	80,088 (86.4)
Yes	17,280 (12.2)	9,053 (11.3)	8,227 (13.5)	4,723 (9.7)	12,557 (13.6)
Dyslipidemia					
No	65,928 (46.7)	38,890 (48.6)	27,038 (44.2)	25,027 (51.6)	40,901 (44.1)
Yes	75,204 (53.3)	41,135 (51.4)	34,069 (55.8)	23,460 (48.4)	51,744 (55.9)
No. of metabolic risk factors					
0	26,113 (18.5)	16,592 (20.7)	9,521 (15.6)	11,545 (23.8)	14,568 (15.7)
1	35,459 (25.1)	20,271 (25.3)	15,188 (24.9)	12,668 (26.1)	22,791 (24.6)
≥ 2	79,560 (56.4)	43,162 (53.9)	36,398 (59.6)	24,274 (50.1)	55,286 (59.7)
Initial antihypertensive drug class[a]					
Renin-angiotensin blocker	98,985 (70.1)	51,717 (64.6)	47,268 (77.4)	28,663 (59.1)	70,322 (75.9)
Calcium channel blocker	67,373 (47.7)	36,835 (46.0)	30,538 (50.0)	21,444 (44.2)	45,929 (49.6)
β-Blocker	14,975 (10.6)	11,204 (14.0)	3,771 (6.2)	8,603 (17.7)	6,372 (6.9)
Diuretics	16,062 (11.4)	9,172 (11.5)	6,890 (11.3)	5,299 (10.9)	10,763 (11.6)
Initial antihypertensive regimen					
Monotherapy	88,874 (63.0)	52,889 (66.1)	35,985 (58.9)	33,794 (69.7)	55,080 (59.5)
Combination therapy	52,258 (37.0)	27,136 (33.9)	25,122 (41.1)	14,693 (30.3)	37,565 (40.5)
Initial single-pill combination use					
No	95,676 (67.8)	56,572 (70.7)	39,104 (64.0)	36,053 (74.4)	59,623 (64.4)
Yes	45,456 (32.2)	23,453 (29.3)	22,003 (36.0)	12,434 (25.6)	33,022 (35.6)

Data are presented as median (interquartile range) or frequency (percent).
BMI, body mass index.
[a]Sum of these proportions exceeds 100% due to the presence of combination therapy.

alcohol drinking (vs. not frequent, OR, 0.98 [95% CI, 0.95–1.00]), and physical inactivity (vs. active, OR, 0.93 [95% CI, 0.91–0.96]) were negatively associated with good adherence. That is, higher income, urban residence, and healthier lifestyles were associated with higher adherence to medication. Additionally, the number of metabolic risk factors (excluding hypertension) was incrementally associated with higher adherence—1 (vs. 0) risk factor: OR, 1.19 (95% CI, 1.15–1.23); ≥ 2 (vs. 0) risk factors: OR, 1.28 (95% CI, 1.24–1.32). Compared to monotherapy initiation, starting with combination therapy was associated with good adherence (OR, 1.31 [95% CI, 1.29–1.34]). Similarly, older age, male sex, higher income,

Table 2. Association between possible factors and good adherence and good persistence

Variables	Good adherence		Good persistence	
	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)
Age (per year)	61,107 (100.0)	1.08 (1.08–1.09)	92,645 (100.0)	1.09 (1.08–1.09)
Sex				
Female	10,144 (36.7)	1.00	15,643 (56.6)	1.00
Male	50,963 (44.9)	1.34 (1.30–1.38)	77,002 (67.8)	1.41 (1.37–1.45)
Household income				
High	20,829 (47.2)	1.00	30,597 (69.4)	1.00
Middle	31,367 (42.2)	0.94 (0.92–0.97)	48,009 (64.6)	0.94 (0.92–0.96)
Low	8,911 (39.2)	0.92 (0.89–0.95)	14,039 (61.8)	0.95 (0.92–0.99)
Residential area				
Urban	51,128 (43.7)	1.00	77,143 (66.0)	1.00
Rural	9,979 (41.3)	0.91 (0.89–0.94)	15,502 (64.1)	0.93 (0.90–0.96)
Current smoking				
No	36,142 (44.6)	1.00	52,965 (65.3)	1.00
Yes	24,965 (41.6)	0.76 (0.74–0.78)	39,680 (66.1)	0.84 (0.82–0.86)
Frequent drinking (≥ 3/week)				
No	47,905 (43.1)	1.00	72,343 (65.2)	1.00
Yes	13,202 (43.8)	0.98 (0.95–1.00)	20,302 (67.4)	1.00 (0.97–1.03)
Physical inactivity (< 1/week)				
No	38,026 (44.2)	1.00	57,186 (66.5)	1.00
Yes	23,081 (41.9)	0.93 (0.91–0.96)	35,459 (64.4)	0.94 (0.92–0.96)
No. of metabolic risk factors				
0	9,521 (36.5)	1.00	14,568 (55.8)	1.00
1	15,188 (42.8)	1.19 (1.15–1.23)	22,791 (64.3)	1.26 (1.22–1.31)
≥ 2	36,398 (45.7)	1.28 (1.24–1.32)	55,286 (69.5)	1.50 (1.45–1.54)
Initial antihypertensive regimen				
Monotherapy	35,985 (40.5)	1.00	55,080 (62.0)	1.00
Combination therapy	25,122 (48.1)	1.31 (1.29–1.34)	37,565 (71.9)	1.48 (1.44–1.51)

OR, odds ratio; CI, confidence interval.

urban residence, non-smoking, higher physical activity, higher metabolic risk, and initial combination therapy were associated with good persistence.

In subgroup analyses stratified by monotherapy and combination therapy, sociodemographic and lifestyle-related factors showed similar patterns of associations to those in the overall population (**Table 3**). This stratification enabled the analysis of the potential effects of each initial treatment, such as the choice of drug class and the use of single-pill combinations. Compared to diuretics as initial monotherapy drug, β-blockers (OR, 1.42 [95% CI, 1.20–1.67]), calcium channel blockers (OR, 4.07 [95% CI, 3.47–4.78]), and renin-angiotensin blockers (OR, 5.24 [95% CI, 4.47–6.15]) were associated with better adherence, in order. Among young patients who started with combination therapy, the use of a single-pill combination was associated with both good adherence (OR, 1.12 [95% CI, 1.07–1.18]) and good persistence (OR, 1.26 [95% CI, 1.19-1.33]).

Sensitivity analyses

Sensitivity analyses reaffirmed the association observed in the primary analyses. First, when the observation period was extended from one year to 2 years, the strength of the associations remained similar or became slightly greater. Notably, the associations between initial antihypertensive regimen and good persistence were more pronounced in this extended analysis (**Supplementary Table 1**). Second, we included participants without health examination results, although they lacked information on lifestyle or metabolic risk factors. Nevertheless, the associations with sociodemographic and clinical factors were persistent in this broader population of young adults with hypertension (**Supplementary Table 2**).

Table 3. Subgroup analyses according to the initial regimen

Variables	Participants with monotherapy		Participants with combination therapy	
	Good adherence (*n* = 35,985)	Good persistence (*n* = 25,122)	Good adherence (*n* = 55,080)	Good persistence (*n* = 37,565)
Age (per year)	1.07 (1.07–1.08)	1.08 (1.07–1.08)	1.08 (1.08–1.09)	1.09 (1.09–1.10)
Sex				
Female	1.00	1.00	1.00	1.00
Male	1.22 (1.17–1.27)	1.28 (1.24–1.33)	1.08 (1.02–1.14)	1.02 (0.96–1.08)
Household income				
High	1.00	1.00	1.00	1.00
Middle	0.97 (0.94–1.00)	0.96 (0.93–0.99)	0.88 (0.84–0.92)	0.86 (0.82–0.90)
Low	0.96 (0.92–1.00)	0.99 (0.94–1.03)	0.82 (0.77–0.86)	0.82 (0.77–0.88)
Residential area				
Urban	1.00	1.00	1.00	1.00
Rural	0.93 (0.89–0.96)	0.95 (0.91–0.98)	0.89 (0.85–0.93)	0.88 (0.84–0.93)
Current smoking				
No	1.00	1.00	1.00	1.00
Yes	0.76 (0.74–0.79)	0.86 (0.83–0.88)	0.77 (0.74–0.80)	0.84 (0.81–0.88)
Frequent drinking				
No	1.00	1.00	1.00	1.00
Yes	0.96 (0.93–1.00)	1.00 (0.96–1.04)	0.96 (0.92–1.00)	0.95 (0.91–0.99)
Physical inactivity				
No	1.00	1.00	1.00	1.00
Yes	0.94 (0.92–0.97)	0.95 (0.92–0.98)	0.93 (0.89–0.96)	0.92 (0.88–0.96)
No. of metabolic risk factors				
0	1.00	1.00	1.00	1.00
1	1.12 (1.08–1.17)	1.17 (1.13–1.22)	1.08 (1.02–1.14)	1.13 (1.06–1.21)
≥ 2	1.13 (1.09–1.18)	1.30 (1.25–1.35)	1.12 (1.06–1.18)	1.27 (1.20–1.34)
Initial monotherapy drug class				
Diuretics	1.00	1.00	-	-
β-Blocker	1.42 (1.20–1.67)	1.13 (1.00–1.28)	-	-
Calcium channel blocker	4.07 (3.47–4.78)	3.11 (2.76–3.50)	-	-
Renin-angiotensin blocker	5.24 (4.47–6.15)	4.19 (3.73–4.72)	-	-
Initial single-pill combination use				
No	-	-	1.00	1.00
Yes	-	-	1.12 (1.07–1.18)	1.26 (1.19–1.33)

Values are presented as odds ratio (95% confidence interval).

DISCUSSION

This nationwide study investigated potential factors associated with medication adherence and persistence in young adults newly treated with hypertension. Overall, medication adherence was 43.3% and persistence was 65.6% during the first year of treatment. Older age, male sex, higher income, urban residence, healthier lifestyles, and the number of metabolic risk factors were significantly associated with a higher PDC and a shorter discontinuation, indicating good adherence and persistence. Furthermore, medication initiation with combination therapy was associated with better medication adherence, especially when using a single-pill combination.

According to the Korea Hypertension Fact Sheet 2020, 1.3 million Korean adults aged 20–39 had hypertension, and a total of 4.7 million young Korean adults had non-optimal blood pressure. However, only 300,000 sought medical care, and 100,000 received persistent treatment, leaving 4 out of 10 Korean adults with unattended hypertension in their 20s and 30s. Even when treated, the adherence rate was only 40% among those aged 20–39, in contrast to > 70% among those aged 65 or older. Consequently, less than 2 out of 10 young adults with hypertension had their blood pressure controlled below 140/90 mmHg. However,

when treated for at least 20 days per month, the control rate among young patients was > 70% and on par with that of other age groups, suggesting that poor blood pressure control in the young population is largely attributable to suboptimal treatment and adherence [10,30].

A previous longitudinal study examined the relationship between nonadherence to antihypertensive medication and premature CVD events in young adults aged 20 to 44 [14]. The study followed 123,390 individuals and found that those with poor adherence had a 1.6-fold higher hazard for developing CVD, compared to adherent individuals [14]. The dose-response relationship was also observed between adherence quartiles and CVD risk, underscoring the importance of facilitating adherence in young patients to prevent long-term cardiovascular complications [14]. However, that study did not report which factors were associated with good or poor medication adherence in young adults with hypertension. The current study extends the existing knowledge by identifying the sociodemographic, lifestyle, and therapy-related factors associated with medication adherence, which may, in turn, be linked to CVD risk.

Our findings on sociodemographic, lifestyle-related, and clinical factors largely align with previous research. Prior studies have consistently identified older age and higher income as determinants of good treatment adherence [31-33]. Data on the effects of sex and urbanicity, however, have been conflicting, potentially due to ethnic differences [31,32,34]. Our study demonstrated a significant association between healthier lifestyles and good adherence and persistence. Similar positive associations between healthy behaviors and medication adherence have been reported in other diseases. For instance, a study on elderly patients with chronic diseases (e.g., hypertension, diabetes, or hyperlipidemia) showed that individuals who did not smoke, avoided heavy drinking, and maintained regular physical activity were more likely to adhere to medication across various diseases [35]. Additionally, the current study found that a higher metabolic risk profile was associated with greater medication adherence and persistence. This may, at least in part, be explained by an elevated perception of risk, prompting proactive efforts to mitigate it [36], and reduced therapeutic inertia against treatment persistence or intensification [37]. Notably, this study found only a small residual association of income or residential area with medication adherence after adjusting for potential confounders and mediators (e.g., low vs. high income: crude OR, 0.72; adjusted OR, 0.92). This suggests that a significant portion of the association between socioeconomic factors and medication adherence may be explained by differences in lifestyle-related and clinical factors by socioeconomic status. However, the residual association indicates that low socioeconomic status remains an independent predictor of poor medication adherence among young patients with hypertension.

Medication adherence is influenced not only by patient-related factors but also by the treatment itself. Lower doses, simple dosing schedules, combination therapy, and the use of angiotensin-converting enzyme inhibitors or angiotensin receptor blockers were associated with better adherence and persistence in prior studies [3,28,38-40]. While the side effects of medication are easily noticeable, high blood pressure often does not cause immediate discomfort. This can lead to patients readily discontinuing their medication, particularly young adults who generally have fewer health concerns [38,39]. Moreover, a meta-analysis including 30,295 patients found that the use of single-pill combination was associated with a 29% higher medication compliance and persistence compared to free-equivalent combination [41]. Better adherence in single-pill combination users may be attributed to the reduced pill burden and simplified regimen, despite offering less flexibility in prescriptions and complicating the identification of the causes of side effects [42,43].

Our study highlights the need for tailored strategies to improve medication adherence for young adults with hypertension. First, low medication adherence in this population warrants greater attention and targeted efforts for improvement. Major life transitions in young adulthood—such as attending college, joining the military, starting a career, or getting married—may introduce competing priorities that disrupt consistent medication adherence [44]. Moreover, as hypertension is largely asymptomatic, young adults who are generally healthier and less health-conscious may underestimate the necessity and benefits of treatment [45]. To address these challenges, adherence strategies specifically tailored to young adults should be developed. Second, understanding key factors associated with medication adherence may help identify young hypertensive patients who require more intensive adherence support. Individuals who are female, have low income, live in rural areas, currently smoke, drink alcohol frequently, or are physically inactive are expected to benefit from closer monitoring and more targeted adherence interventions. Furthermore, drug class selection—particularly the use of single-pill combination therapy—should be considered to enhance medication adherence in young adults with hypertension.

Our study has several strengths. First, we utilized a nationwide database covering the entire Korean population, allowing us to include all young adults newly treated for hypertension in Korea. Second, large sample size enabled detailed stratifications of and adjustment for potential determinants. Third, among various methods for measuring medication adherence—such as self-reporting, metabolite monitoring, and biological markers—methods using electronic prescription claims data are particularly useful for analyzing large populations and offering objectivity and statistical power [4,46,47]. Last, we employed 2 separate measurements, adherence (PDC) and persistence (last gap). These metrics captured different features of compliance; adherence represents the overall extent of medication coverage within a specified period, while persistence refers to a long-term continuation [24].

Some limitations should also be considered. First, unmeasured confounders cannot be included and may have affected the observed associations. Second, our primary analyses were based on participants with health examination results. This selection was intended to investigate the associations with lifestyle and biometric variables but may limit the generalizability of our findings to a subset of young hypertensive adults who actively engaged in the national health screening. Hence, sensitivity analyses were performed by including those with and without health examination data and showed consistent results. Likewise, extending the observation period confirmed that the associations with 2-year adherence and persistence remained stable.

CONCLUSIONS

Promoting adherence to antihypertensive medication can be challenging due to the asymptomatic and lifelong nature of hypertension. Despite low adherence in young adults, we identified potential sociodemographic, lifestyle, and therapy-related factors associated with good adherence and persistence to antihypertensives in this population. In particular, the initial use of single-pill combination therapy may promote adherence in young patients, although further investigation is needed to evaluate its long-term clinical outcomes.

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SUPPLEMENTARY MATERIALS

Supplementary Table 1
Sensitivity analyses: 2-year adherence and persistence

Supplementary Table 2
Sensitivity analyses: including participants without health examination

Supplementary Fig. 1
Flowchart of sample selection.

Supplementary Fig. 2
Calculation of the PDC and the last gap.

Supplementary Fig. 3
Prevalence of good adherence and persistence to antihypertensive medication among young new users.

REFERENCES

1. Ford ES, Ajani UA, Croft JB, Critchley JA, Labarthe DR, Kottke TE, et al. Explaining the decrease in U.S. deaths from coronary disease, 1980-2000. N Engl J Med. 2007;356:2388-98. PUBMED | CROSSREF
2. Bosworth HB, Granger BB, Mendys P, Brindis R, Burkholder R, Czajkowski SM, et al. Medication adherence: a call for action. Am Heart J. 2011;162:412-24. PUBMED | CROSSREF
3. World Health Organization. Adherence to long-term therapies: evidence for action. Geneva: World Health Organization; 2003.
4. Osterberg L, Blaschke T. Adherence to medication. N Engl J Med. 2005;353:487-97. PUBMED | CROSSREF
5. Vrijens B, Vincze G, Kristanto P, Urquhart J, Burnier M. Adherence to prescribed antihypertensive drug treatments: longitudinal study of electronically compiled dosing histories. BMJ. 2008;336:1114-7. PUBMED | CROSSREF
6. Vrijens B, Antoniou S, Burnier M, de la Sierra A, Volpe M. Current situation of medication adherence in hypertension. Front Pharmacol. 2017;8:100. PUBMED | CROSSREF
7. Burt VL, Whelton P, Roccella EJ, Brown C, Cutler JA, Higgins M, et al. Prevalence of hypertension in the US adult population. Results from the Third National Health and Nutrition Examination Survey, 1988-1991. Hypertension. 1995;25:305-13. PUBMED | CROSSREF
8. Chowdhury R, Khan H, Heydon E, Shroufi A, Fahimi S, Moore C, et al. Adherence to cardiovascular therapy: a meta-analysis of prevalence and clinical consequences. Eur Heart J. 2013;34:2940-8. PUBMED | CROSSREF
9. Corrao G, Parodi A, Nicotra F, Zambon A, Merlino L, Cesana G, et al. Better compliance to antihypertensive medications reduces cardiovascular risk. J Hypertens. 2011;29:610-8. PUBMED | CROSSREF
10. The Korean Society of Hypertension–Hypertension Epidemiology Research Working Group. Korea hypertension fact sheet 2022. Seoul: The Korean Society of Hypertension; 2022.
11. Yang Q, Chang A, Ritchey MD, Loustalot F. Antihypertensive medication adherence and risk of cardiovascular disease among older adults: a population-based cohort study. J Am Heart Assoc. 2017;6:e006056. PUBMED | CROSSREF

12. Krousel-Wood MA, Muntner P, Islam T, Morisky DE, Webber LS. Barriers to and determinants of medication adherence in hypertension management: perspective of the cohort study of medication adherence among older adults. Med Clin North Am. 2009;93:753-69. PUBMED | CROSSREF
13. Gast A, Mathes T. Medication adherence influencing factors-an (updated) overview of systematic reviews. Syst Rev. 2019;8:112. PUBMED | CROSSREF
14. Lee H, Yano Y, Cho SMJ, Heo JE, Kim DW, Park S, et al. Adherence to antihypertensive medication and incident cardiovascular events in young adults with hypertension. Hypertension. 2021;77:1341-9. PUBMED | CROSSREF
15. Cheol Seong S, Kim YY, Khang YH, Park HJ, Kang HJ, Lee H, et al. Data resource profile: the National Health Information Database of the National Health Insurance Service in South Korea. Int J Epidemiol 2017;46:799-800. PUBMED | CROSSREF
16. Lee H, Yano Y, Cho SMJ, Park JH, Park S, Lloyd-Jones DM, et al. Cardiovascular risk of isolated systolic or diastolic hypertension in young adults. Circulation. 2020;141:1778-86. PUBMED | CROSSREF
17. Lee H, Park JH, Floyd JS, Park S, Kim HC. Combined effect of income and medication adherence on mortality in newly treated hypertension: nationwide study of 16 million person-years. J Am Heart Assoc. 2019;8:e013148. PUBMED | CROSSREF
18. Tajeu GS, Kent ST, Huang L, Bress AP, Cuffee Y, Halpern MT, et al. Antihypertensive medication nonpersistence and low adherence for adults <65 years initiating treatment in 2007-2014. Hypertension. 2019;74:35-46. PUBMED | CROSSREF
19. Bosworth H, Allen K, Morey MC, Yancy WS, Voils CI, Rohrer L, et al. Improving patient treatment adherence: a clinician's guide. New York: Springer; 2010.
20. Kim HC, Cho SMJ, Lee H, Lee HH, Baek J, Heo JE, et al. Korea hypertension fact sheet 2020: analysis of nationwide population-based data. Clin Hypertens. 2021;27:8. PUBMED | CROSSREF
21. Kim HC, Lee H, Lee HH, Seo E, Kim E, Han J, et al. Korea hypertension fact sheet 2021: analysis of nationwide population-based data with special focus on hypertension in women. Clin Hypertens. 2022;28:1. PUBMED | CROSSREF
22. Kim HC, Lee H, Lee HH, Lee G, Kim E, Song M, et al. Korea hypertension fact sheet 2022: analysis of nationwide population-based data with a special focus on hypertension in the elderly. Clin Hypertens. 2023;29:22. PUBMED | CROSSREF
23. Kim HC, Lee H, Lee HH, Son D, Cho M, Shin S, et al. Korea hypertension fact sheet 2023: analysis of nationwide population-based data with a particular focus on hypertension in special populations. Clin Hypertens. 2024;30:7. PUBMED | CROSSREF
24. Raebel MA, Schmittdiel J, Karter AJ, Konieczny JL, Steiner JF. Standardizing terminology and definitions of medication adherence and persistence in research employing electronic databases. Med Care. 2013;51:S11-21. PUBMED | CROSSREF
25. Burnier M, Egan BM. Adherence in hypertension. Circ Res. 2019;124:1124-40. PUBMED | CROSSREF
26. Andrade SE, Kahler KH, Frech F, Chan KA. Methods for evaluation of medication adherence and persistence using automated databases. Pharmacoepidemiol Drug Saf. 2006;15:565-74. PUBMED | CROSSREF
27. Buysman EK, Liu F, Hammer M, Langer J. Impact of medication adherence and persistence on clinical and economic outcomes in patients with type 2 diabetes treated with liraglutide: a retrospective cohort study. Adv Ther. 2015;32:341-55. PUBMED | CROSSREF
28. Qvarnström M, Kahan T, Kieler H, Brandt L, Hasselström J, Boström KB, et al. Persistence to antihypertensive drug classes: a cohort study using the Swedish Primary Care Cardiovascular Database (SPCCD). Medicine (Baltimore). 2016;95:e4908. PUBMED | CROSSREF
29. Kronish IM, Woodward M, Sergie Z, Ogedegbe G, Falzon L, Mann DM. Meta-analysis: impact of drug class on adherence to antihypertensives. Circulation. 2011;123:1611-21. PUBMED | CROSSREF
30. The Korean Society of Hypertension–Hypertension Epidemiology Research Working Group. Korea hypertension fact sheet 2023. Seoul: The Korean Society of Hypertension; 2023.
31. Morris AB, Li J, Kroenke K, Bruner-England TE, Young JM, Murray MD. Factors associated with drug adherence and blood pressure control in patients with hypertension. Pharmacotherapy. 2006;26:483-92. PUBMED | CROSSREF
32. Lewis LM. Factors associated with medication adherence in hypertensive blacks: a review of the literature. J Cardiovasc Nurs. 2012;27:208-19. PUBMED | CROSSREF
33. Krousel-Wood M, Thomas S, Muntner P, Morisky D. Medication adherence: a key factor in achieving blood pressure control and good clinical outcomes in hypertensive patients. Curr Opin Cardiol. 2004;19:357-62. PUBMED | CROSSREF

34. Pan J, Wu L, Wang H, Lei T, Hu B, Xue X, et al. Determinants of hypertension treatment adherence among a Chinese population using the therapeutic adherence scale for hypertensive patients. Medicine (Baltimore). 2019;98:e16116. PUBMED | CROSSREF

35. Han E, Sohn HS, Lee JY, Jang S. Health behaviors and medication adherence in elderly patients. Am J Health Promot. 2017;31:278-86. PUBMED | CROSSREF

36. Krueger KP, Berger BA, Felkey B. Medication adherence and persistence: a comprehensive review. Adv Ther. 2005;22:313-56. PUBMED | CROSSREF

37. Jung MH, Ihm SH. Improving the quality of hypertension management: multifaceted approach. Korean Circ J. 2019;49:528-31. PUBMED | CROSSREF

38. Nuesch R, Schroeder K, Dieterle T, Martina B, Battegay E. Relation between insufficient response to antihypertensive treatment and poor compliance with treatment: a prospective case-control study. BMJ. 2001;323:142-6. PUBMED | CROSSREF

39. Kjellgren KI, Ahlner J, Säljö R. Taking antihypertensive medication--controlling or co-operating with patients? Int J Cardiol. 1995;47:257-68. PUBMED | CROSSREF

40. Patel BV, Remigio-Baker RA, Thiebaud P, Preblick R, Plauschinat C. Improved persistence and adherence to diuretic fixed-dose combination therapy compared to diuretic monotherapy. BMC Fam Pract. 2008;9:61. PUBMED | CROSSREF

41. Gupta AK, Arshad S, Poulter NR. Compliance, safety, and effectiveness of fixed-dose combinations of antihypertensive agents: a meta-analysis. Hypertension. 2010;55:399-407. PUBMED | CROSSREF

42. Claxton AJ, Cramer J, Pierce C. A systematic review of the associations between dose regimens and medication compliance. Clin Ther. 2001;23:1296-310. PUBMED | CROSSREF

43. Poulter NR, Borghi C, Parati G, Pathak A, Toli D, Williams B, et al. Medication adherence in hypertension. J Hypertens. 2020;38:579-87. PUBMED | CROSSREF

44. Johnson HM, Warner RC, Bartels CM, LaMantia JN. "They're younger… it's harder." Primary providers' perspectives on hypertension management in young adults: a multicenter qualitative study. BMC Res Notes. 2017;10:9. PUBMED | CROSSREF

45. Hamrahian SM, Falkner B. Approach to hypertension in adolescents and young adults. Curr Cardiol Rep. 2022;24:131-40. PUBMED | CROSSREF

46. Prieto-Merino D, Mulick A, Armstrong C, Hoult H, Fawcett S, Eliasson L, et al. Estimating proportion of days covered (PDC) using real-world online medicine suppliers' datasets. J Pharm Policy Pract. 2021;14:113. PUBMED | CROSSREF

47. Lehmann A, Aslani P, Ahmed R, Celio J, Gauchet A, Bedouch P, et al. Assessing medication adherence: options to consider. Int J Clin Pharm. 2014;36:55-69. PUBMED | CROSSREF