


ORIGINAL PAPER

The importance of frequent return visits and hypertension control among US young adults: a multidisciplinary group practice observational study

Cecile C. King MD¹ | Christie M. Bartels MD, MS^{1,2} | Elizabeth M. Magnan MD, PhD³ |
Jennifer T. Fink MS, PhD⁴ | Maureen A. Smith MD, PhD, MPH^{2,5,6} |
Heather M. Johnson MD, MS^{1,2} 

¹Department of Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

²Health Innovation Program, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

³Department of Family and Community Medicine, University of California – Davis, Sacramento, CA, USA

⁴Department of Health Informatics and Administration, University of Wisconsin-Milwaukee, Milwaukee, WI, USA

⁵Department of Family Medicine and Community Health, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

⁶Department of Population Health Sciences, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA

Correspondence

Heather M. Johnson, MD, MS, Department of Medicine, Division of Cardiovascular Medicine, University of Wisconsin School of Medicine and Public Health, Madison, WI, USA.
Email: hm2@medicine.wisc.edu

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Young adults (aged 18 to 39 years) have the lowest hypertension control rates compared with older adults. Shorter follow-up encounter intervals are associated with faster hypertension control rates in older adults; however, optimal intervals are unknown for young adults. The study objective was to evaluate the relationship between ambulatory blood pressure encounter intervals (average number of provider visits with blood pressures over time) and hypertension control rates among young adults with incident hypertension. A retrospective analysis was conducted of patients aged 18 to 39 years ($n = 2990$) with *incident* hypertension using Kaplan-Meier survival and Cox proportional hazards analyses over 24 months. Shorter encounter intervals were associated with higher hypertension control: <1 month (91%), 1 to 2 months (76%), 2 to 3 months (65%), 3 to 6 months (40%), and >6 months (13%). Young adults with shorter encounter intervals also had lower medication initiation, supporting the effectiveness of lifestyle modifications. Sustainable interventions for timely young adult follow-up are essential to improve hypertension control in this hard-to-reach population.

1 | INTRODUCTION

Hypertension is a potentially reversible contributor to more than 400 000 deaths annually in the United States.¹ Historic blood pressures (BPs) predict the incidence of future cardiovascular events. Conversely, hypertension control can decrease rates of cardiovascular morbidity and mortality.² Approximately 20% of young adult men and 15% of young adult women (aged 18 to 39 years)³ have hypertension.⁴ Unfortunately, hypertension is an underrecognized cardiovascular risk factor in young adults, contributing to premature heart failure, strokes, and chronic kidney disease.⁵⁻⁷ Overall, young adults have the lowest hypertension control rates when compared with middle-aged and older adults,⁸ with <40% of young adults with hypertension achieving BP control.

Our previous studies demonstrated that young adults have lower rates of receiving an initial hypertension diagnosis and achieving hypertension control compared with older populations.^{8,9} Despite quality measures for hypertension care,¹⁰ the optimal return encounter interval (average number of provider-patient BP encounters over time) to achieve hypertension control among young adults remains unknown.^{11,12} Encounter intervals also vary significantly between providers.¹³⁻¹⁵ Ambulatory encounters increase opportunities to reinforce hypertension lifestyle modifications, address patients' concerns, and initiate and/or titrate antihypertensive medication if necessary.¹⁶ Prior research demonstrated that shorter visit intervals were positively associated with hypertension control among middle-aged adults (mean age 54.7±14.3 years). However, optimal BP encounter intervals or interventions have not been identified for young adults, a high-risk population with longer exposure to high BPs.¹¹ To address this critical gap in hypertension care among young adults, our objective was to evaluate the relationship of ambulatory encounter intervals and rates of hypertension control among young adults with incident hypertension.

2 | METHODS

2.1 | Sample

The University of Wisconsin-Madison Health Sciences institutional review board approved this study with a waiver of written informed consent. This retrospective cohort analysis used electronic health record data of patients with uncontrolled hypertension from a large, Midwestern, multidisciplinary academic group practice. To construct the sample (Figure 1), we identified all patients 18 to 39 years who met criteria from the Wisconsin Collaborative for Healthcare Quality (WCHQ)^{17,18} for being "currently managed" in the healthcare system between January 1, 2008, and December 31, 2011. WCHQ is a voluntary consortium of Wisconsin healthcare organizations committed to publicly reporting performance measures of quality and affordability of healthcare services.¹⁹ Per WCHQ criteria, eligible currently managed patients had to have two or more billable office encounters in an outpatient, nonurgent, primary care setting, or one primary care and one office encounter in an urgent care setting, in the 3 years prior to study enrollment, with at least one visit in the prior 2 years.²⁰

Electronic health records were assessed for the date a patient met the Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure (JNC 7) criteria for a new diagnosis of hypertension¹ (incident hypertension), meaning they had not received a previous diagnosis of or treatment for hypertension. JNC 7 criteria were used because they were the established US hypertension guidelines during the reporting period. A patient was determined as meeting hypertension eligibility criteria based on electronic health record data if there were: (1) three or more elevated outpatient BP measurements from three separate dates, ≥30 days apart, but within a 2-year span (systolic BP ≥140 mm Hg or diastolic BP ≥90 mm Hg) or (2) two elevated BPs^{21,22} (systolic BP ≥160 mm Hg or diastolic BP ≥100 mm Hg), ≥30 days apart within a 2-year period.^{8,9,23-25} If more than one BP was taken at a visit, the average was used.⁸ Hospital and emergency department BPs were excluded to avoid falsely elevated BPs. After meeting criteria for incident hypertension, patients were then excluded if they did not receive an electronic health record diagnosis of hypertension based on Tu criteria²⁶ or if they had less than 6 months of follow-up (Figure 1). The Tu algorithm for administrative data is used to define patients who have been diagnosed with hypertension using the following International Classification of Diseases, Ninth Revision (ICD-9) codes:²⁷ 401.x (essential hypertension), 402.x (hypertensive heart disease), 403.x (hypertensive renal disease), 404.x (hypertensive heart and renal disease), and 405.x (secondary hypertension).

Each patient who met all eligibility criteria received an "index date" (the first date all criteria were met). A 365-day period prior to this index date was the "baseline period" to assess patients' comorbidities and healthcare utilization. Patients were followed for 24 months to account for less frequent ambulatory visits among younger populations⁸ (eg, patients who may have returned solely for semiannual physicals). Patients continued to accrue time in the study from the index date until they achieved the primary outcome (hypertension control) or censoring occurred (death, end of primary care management, pregnancy, or end of study). Censoring for "end of primary care management" accounted for disruptions in healthcare access in this young population (eg, change in insurance, residence). Patients who were pregnant during the study were excluded 1 year before, during, and 1 year following pregnancy using a modified Manson approach²⁸ (n = 16; 0.54%). The final sample included 2990 currently managed young adults with incident hypertension (Figure 1).

2.2 | Primary explanatory variable

The return encounter intervals were calculated as visits over 24 months and categorized according to prior methodology:¹² <1 month between visits, 1 to 2 months, 2 to 3 months, 3 to 6 months, and >6 months between visits. Ambulatory return visits required a BP entry into the electronic health record for that visit and included physicians (faculty, resident, fellow), nurse practitioners, and physician assistants in primary care clinics (defined in this academic center as Family Medicine/Family Practice, Internal Medicine, Obstetrics/Gynecology, and Pediatrics/Adolescent Medicine). Urgent care and

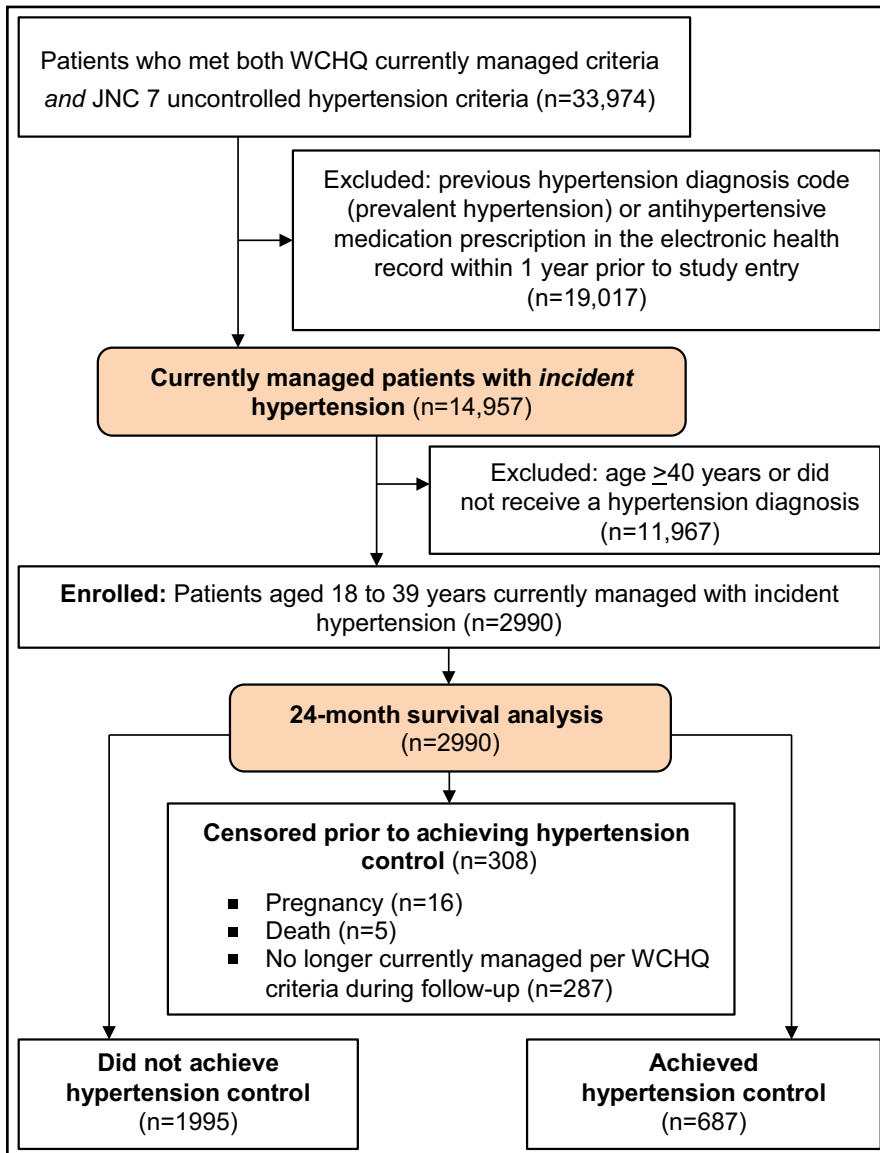


FIGURE 1 Study sample: enrollment and analysis. WCHQ indicates Wisconsin Collaborative for Healthcare Quality; JNC 7, Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure

emergency department BPs were not included for cohort development or for study follow-up; the goal was to decrease the inclusion of BPs during acute illness/injury and to reflect routine ambulatory primary care.

2.3 | Primary outcome variable

The primary outcome was time (days) from the index date to achieving hypertension control, defined as the first of three consecutive normal BPs (<140/90 mm Hg) on three separate dates.²⁴ To account for BP variability, multiple clinic BPs were used to define hypertension control since 24-hour ambulatory BP monitoring data were not available. Results are reported in months.

2.4 | Other explanatory variables

Patient and provider variables to examine barriers to hypertension control were selected based on an established conceptual model for

clinical inertia.²⁹ Patient-related factors included sociodemographics (age, sex, race/ethnicity, marital status, and Medicaid use during the baseline or study period), behavioral risk factors (baseline tobacco use and body mass index [BMI]), and comorbidities. Patients' race/ethnicity was included because of the increased prevalence of hypertension among young black patients.³⁰ All of the patients self-classified their race/ethnicity in the electronic health record (white, black, Asian, Hispanic/Latino, other [Native Hawaiian, Pacific Islander, multiracial], or unknown). Patient comorbidities were assessed at baseline using the following established algorithms: hyperlipidemia (ICD-9 codes: 272.0-272.4),³¹ diabetes mellitus with/without complications (ICD-9 codes: 250.00-250.93, 357.2, 362.0-362.02, 366.41),³² chronic kidney disease (ICD-9 codes: 016.0, 095.4, 189.0, 189.9, 223.0, 236.91, 250.4, 271.4, 274.1, 283.11, 403.X1, 404.X2, 404.X3, 440.1, 442.1, 447.3, 572.4, 580-588, 591, 642.1, 646.2, 753.12-753.17, 753.19, 753.2, 794.4),³³ and mental health conditions (depression [ICD-9 codes: 296.2X, 296.3X, 300.4X]³⁴ and anxiety [ICD-9 codes: 300.0-300.02, 300.09, 300.21-300.23, 300.3, 309.24, 309.81]).³⁴ Elixhauser

TABLE 1 Baseline demographics of young adults (aged 18 to 39 years) with incident hypertension by encounter interval (N = 2990)

	Total population (N = 2990)	By encounter interval					P value
		<1 mo (n = 402)	1–2 mo (n = 568)	2–3 mo (n = 463)	3–6 mo (n = 768)	>6 mo (n = 789)	
Patient characteristics							
Age, mean (SD)	32 (5.4)	32 (5.1)	32 (5.4)	32 (5.2)	32 (5.4)	31 (5.6)	.06
Men, No. (%)	1763 (59)	164 (41)	254 (45)	263 (57)	489 (64)	593 (75)	<.001
Race/ethnicity, No. (%)							<.001
White	2474 (83)	313 (78)	460 (81)	370 (80)	650 (85)	681 (86)	
Nonwhite ^a	516 (17)	89 (22)	108 (19)	93 (20)	118 (15)	108 (14)	
Marital status, No. (%)							.06
Single/divorced/widowed	1642 (55)	227 (56)	337 (59)	260 (56)	399 (52)	419 (53)	
Married/partnered	1348 (45)	175 (44)	231 (41)	203 (44)	369 (48)	370 (47)	
Primary spoken language, No. (%)							<.001
English	2738 (92)	370 (92)	547 (96)	441 (95)	723 (94)	657 (83)	
Other	252 (8.4)	32 (8.0)	21 (3.7)	22 (4.8)	45 (5.9)	132 (17)	
Tobacco use, No. (%)							.16
Current tobacco use	660 (22)	94 (23)	134 (24)	114 (25)	148 (19)	170 (22)	
Never/former tobacco use	2330 (78)	308 (77)	434 (76)	349 (75)	620 (81)	619 (78)	
BMI, mean (SD), kg/m ²	33 (8.6)	33 (9.0)	34 (9.1)	34 (9.4)	33 (8.2)	33 (7.7)	.18
BMI categories, No. (%)							.66
BMI <25 kg/m ²	361 (12)	58 (14)	75 (13)	51 (11)	85 (11)	92 (12)	
BMI 25–29 kg/m ²	724 (24)	97 (24)	141 (25)	119 (26)	187 (24)	180 (23)	
BMI ≥30 kg/m ²	1905 (64)	247 (61)	352 (62)	293 (63)	496 (65)	517 (66)	
On Medicaid ever, ^b No. (%)	524 (18)	117 (29)	134 (24)	91 (20)	101 (13)	81 (10)	<.001
JNC 7 hypertension stage, ^c No. (%)							<.001
Stage 1: 140–159/90–99 mm Hg	2317 (77)	337 (84)	456 (80)	365 (79)	597 (78)	562 (71)	
Stage 2: ≥160–179/≥100 mm Hg	673 (23)	65 (16)	112 (20)	98 (21)	171 (22)	227 (29)	
Baseline SBP tertiles, No. (%)							<.001
Lowest SBP tertile	1051 (35)	173 (43)	217 (38)	173 (37)	242 (32)	246 (31)	
Middle SBP tertile	943 (32)	126 (31)	171 (30)	152 (33)	250 (33)	244(31)	
Highest SBP tertile	996 (33)	103 (26)	180 (32)	138 (29)	276 (36)	299(38)	
Baseline DBP tertiles, No. (%)							.02
Lowest DBP tertile	1079 (36)	157 (39)	195 (34)	171 (37)	274 (36)	282 (36)	
Middle DBP tertile	993 (33)	148 (37)	202 (36)	149 (32)	262 (34)	232 (29)	
Highest DBP tertile	918 (31)	97 (24)	171 (30)	143 (31)	232 (30)	275 (35)	
Baseline comorbid conditions, No. (%)							
Hyperlipidemia	240 (8.0)	49 (12)	38 (6.7)	45 (9.7)	64 (8.3)	44 (5.6)	.001
Diabetes mellitus	93 (3.1)	19 (4.7)	20 (3.5)	20 (4.3)	25 (3.3)	9 (1.1)	.003
Anxiety and/or depression	738 (25)	166 (41)	173 (30)	112 (24)	163 (21)	124 (16)	<.001

(Continues)

TABLE 1 (Continued)

	Total population (N = 2990)	By encounter interval					P value
		<1 mo (n = 402)	1–2 mo (n = 568)	2–3 mo (n = 463)	3–6 mo (n = 768)	>6 mo (n = 789)	
Low prevalence conditions ^d	335 (11)	88 (22)	89 (16)	59 (13)	64 (8.3)	35 (4.4)	<.001
ACG ^e score, young, mean (SD)	1.1 (1.2)	1.8 (1.9)	1.3 (1.4)	1.1 (1.2)	0.8 (0.9)	0.7 (0.6)	<.001
ACG ^e score tertiles, young, No. (%)							<.001
Lowest ACG tertile	1035 (35)	52 (13)	119 (21)	129 (28)	323 (42)	412 (52)	
Middle ACG tertile	959 (32)	124 (31)	180 (32)	160 (35)	252 (33)	243 (31)	
Highest ACG tertile	996 (33)	226 (56)	269 (47)	174 (38)	193 (25)	134 (17)	
Baseline annual ambulatory visit count, all visits, mean (SD)							
Primary care visits	2.5 (2.5)	4.2 (3.6)	2.9 (2.5)	2.5 (2.3)	2.0 (1.9)	1.7 (1.7)	<.001
Specialty care visits	1.3 (1.8)	2.6 (2.9)	1.5 (1.9)	1.2 (1.6)	1.0 (1.3)	0.7 (1.0)	<.001
Urgent care visits	0.9 (1.4)	1.6 (2.1)	1.0 (1.5)	0.9 (1.4)	0.7 (1.2)	0.6 (0.9)	<.001
Provider characteristics							
Specialty providing majority of ambulatory care, No. (%)							.02
Internal medicine	828 (28)	121 (30)	186 (33)	130 (28)	203 (26)	188 (24)	
Family medicine/family practice	1742 (58)	231 (57)	317 (56)	268 (58)	444 (58)	482 (61)	
Other ^f	420 (14)	50 (12)	65 (11)	65 (14)	121 (16)	119 (15)	
Provider age, ^g mean (SD)	43 (10)	43 (10)	43 (11)	43 (11)	43 (10)	43 (10)	.42
Female provider, No. (%)	1361 (46)	216 (54)	300 (53)	226 (49)	322 (42)	297 (38)	<.001

Abbreviations: BMI, body mass index; DBP, diastolic blood pressure; JNC 7, Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure; SBP, systolic blood pressure. Bolded *P* values are statistically significant.

^aNonwhite: black (8.3%), Hispanic/Latino (3.2%), Asian (1.6%), Native Hawaiian/Pacific Islander (1.0%), American Indian/Alaska Native (0.54), and unknown (2.8%).

^bOn Medicaid at any point during the baseline or study period.

^cSeverity of blood pressure elevation at study entry.

^dChronic kidney disease (0.6%), neurologic conditions (1.9%), anemia (0.6%), chronic pulmonary disease (5.2%), thyroid disorders (2.3%), rheumatologic disorders (0.5%), and inflammatory bowel disease (0.4%).

^eAdjusted Clinical Group (ACG) case-mix assessment system.

^fPediatrics/adolescent medicine and obstetrics/gynecology.

^gThe American Medical Association (AMA) is the source for the raw physician data (provider ages only); statistics, tables, or tabulations were prepared by User-Customer (M. Smith; PI: H. Johnson) using 2011 AMA Masterfile data.

and the Medicare Chronic Condition Data Warehouse Administrative algorithms were used to identify chronic pulmonary disease,³⁵ stroke/transient ischemic attack,³⁶ rheumatoid arthritis,³⁷ inflammatory bowel diseases,³⁷ thyroid diseases,³⁵ and deficiency anemias.³⁵ We created an indicator variable for the presence of any of these conditions because of their low prevalence.

Patients' morbidity burden can predict healthcare utilization, which may influence diagnosis and antihypertensive medication initiation rates.^{38,39} Therefore, we used the Johns Hopkins Adjusted Clinical Group (ACG) case-mix system (version 10.0), which assesses morbidity burden to predict future healthcare utilization.^{39,40} The ACG risk score was selected because our study sample contains a diverse mix

of government-insured and privately insured ambulatory young adults. An ACG risk score of 1.0 represents expected healthcare utilization on an individual level according to the patient's age and sex.⁴⁰ The number of primary care, specialty, and urgent care visits were measured in the baseline period. Primary care visits included physician, nurse practitioner, and physician assistant visits in Family Medicine/Family Practice, Internal Medicine, and lower prevalence primary care specialties (Obstetrics/Gynecology, Pediatrics/Adolescent Medicine) to reflect broader primary care options in this younger population.

Patients were assigned to the primary care provider they saw most frequently in outpatient face-to-face evaluation and management visits, as reported in professional service claims.²⁰ Statistical models

additionally controlled for providers' age, specialty (Internal Medicine, Family Medicine/Family Practice, Other), and sex, which were obtained from the provider group's human resource office and/or the American Medical Association (AMA) 2011 Masterfile data.

2.5 | Statistical analysis

Analyses were conducted using SAS version 9.1.3 (SAS Institute, Inc.) and Stata version 13.1 (StataCorp). Baseline comparisons between individuals with different encounter intervals were performed using analysis of variance for continuous variables and chi-square test for categorical descriptive statistics. Univariate Kaplan-Meier survival curves⁴¹ were computed by encounter interval (<1 month, 1–2 months, 2–3 months, 3–6 months, and >6 months) to evaluate the probability of achieving hypertension control, as a function of time since meeting criteria for incident hypertension. Multivariate Cox proportional hazards regression analyses were conducted to obtain adjusted hazard ratios and 95% confidence intervals (CIs) for achieving hypertension control. Robust estimates of variance were used to account for within-cluster correlation.^{42,43} Explanatory variables used in the Cox regression models include patient sociodemographics (age, sex, race, Medicaid use), baseline comorbidities (dyslipidemia, diabetes mellitus, anxiety and/or depression, low prevalence conditions), behavioral risk factors (BMI, tobacco status), healthcare utilization (ACG risk score, baseline visit count), and provider characteristics (specialty). Statistical significance was defined as $P < .002$ after Bonferroni correction for multiple comparisons.⁴⁴ The proportional hazards assumption for each model was tested using a generalized linear regression of the scaled Schoenfeld residuals on functions of time.⁴⁵

2.6 | Data availability

The data set generated and analyzed during the current study is not publicly available as a result of the data use agreement, but is available from the corresponding author upon reasonable request and necessary approvals.

3 | RESULTS

3.1 | Descriptive data

Overall, 2990 patients met inclusion criteria (Figure 1). Table 1 summarizes the study population by average encounter intervals of <1 month, 1 to 2 months, 2 to 3 months, 3 to 6 months, and >6 months. Among the study population of young adults with incident hypertension (mean age, 32 [5.4] years; 59% male), 77% had stage 1 (mild) hypertension, 64% were obese (BMI ≥ 30 kg/m²), and 58% were seen in a Family Medicine or Family Practice clinic. Overall, 13% of young adults had an encounter interval of <1 month, 19% had an encounter interval of 1 to 2 months, 16% an encounter interval of 2 to 3 months, 26% an encounter interval of 3 to 6 months, and 26% an encounter interval of >6 months. Young adults with the shortest encounter interval (<1 month) were more likely to be women (59%),

have stage 1 (mild) hypertension, report Medicaid use, have comorbidities (hyperlipidemia, diabetes mellitus, mental health diagnoses), have higher ACG risk score, and a female provider. The mean number of annual primary care visits during a 12-month calendar year, by encounter interval were: 3.0 (standard deviation [SD], 2.5) visits within the <1-month interval, 3.4 (SD, 2.2) visits within the 1- to 2-month interval, 3.0 (SD, 1.8) visits in the 2- to 3-month interval, 2.4 (SD, 1.5) visits in the 3- to 6-month interval, and 1.6 (SD, 1.1) visits in the >6-month interval. There was a similar relationship between mean number of specialty visits and encounter intervals: 2.0 (SD, 1.9) specialty visits within the <1-month interval, 1.7 (SD, 1.7) visits in the 1- to 2-month interval, 1.3 (SD, 1.4) in the 2- to 3-month interval, 0.93 (SD, 1.1) in the 3- to 6-month interval, and 0.53 (SD, 0.74) in the >6-month interval. During 24 months of follow-up, patients were censored as a result of death ($n = 5$; 0.17%) and if they were no longer currently managed by the healthcare system ($n = 287$; 9.6%).

3.2 | Incident hypertension control rates by encounter interval

Among all patients aged 18 to 39 years, 52% ($n = 1543$) achieved hypertension control within 24 months after meeting criteria for incident hypertension. The Kaplan-Meier curve (Figure 2) demonstrated that young adults with a <1-month encounter frequency had the highest rates of hypertension control (91%), compared with young adults with longer encounter intervals: 1 to 2 months (76%), 2 to 3 months (65%), 3 to 6 months (40%), and >6 months (13%). The median (25th–75th percentile) time in months to hypertension control by encounter interval was: <1-month encounter interval (2.8 [95% CI, 1.8–3.9] months to control), 1- to 2-month interval (7.1 [95% CI, 5.1–11.3] months), 2- to 3-month interval (10.5 [95% CI, 8.5–14.4] months), 3- to 6-month interval (16.4 [95% CI 12.4–22.6] months), and >6-month interval (23.9 [95% CI, 22.5–24.1] months).

3.3 | Predictors of time to hypertension control by encounter interval

Unadjusted Cox proportional hazards models (Table 2) demonstrated that young adults with incident hypertension had a significantly lower rate of achieving hypertension control as the encounter interval increased. After adjusting for patient demographics, tobacco use, BMI, and comorbidities, young adults seen at the 1- to 2-month interval had a 76% lower rate of achieving hypertension control (hazard ratio, 0.24; 95% CI, 0.18–0.31) and an even lower rate in the >6-month interval (hazard ratio, 0.008; 95% CI, 0.005–0.011). Current tobacco use, obesity (BMI ≥ 30 kg/m²) and a high ACG risk score predicted a lower likelihood of achieving hypertension control at $P < .05$, but not after applying the conservative Bonferroni correction. Young adults with higher baseline systolic and diastolic BP had a significantly lower likelihood of achieving hypertension control. Provider factors (age, sex, and specialty) were not significant predictors for hypertension control.

Over 24 months, 26% ($n = 772$) of young adults with incident hypertension were started on one or more antihypertensive medication

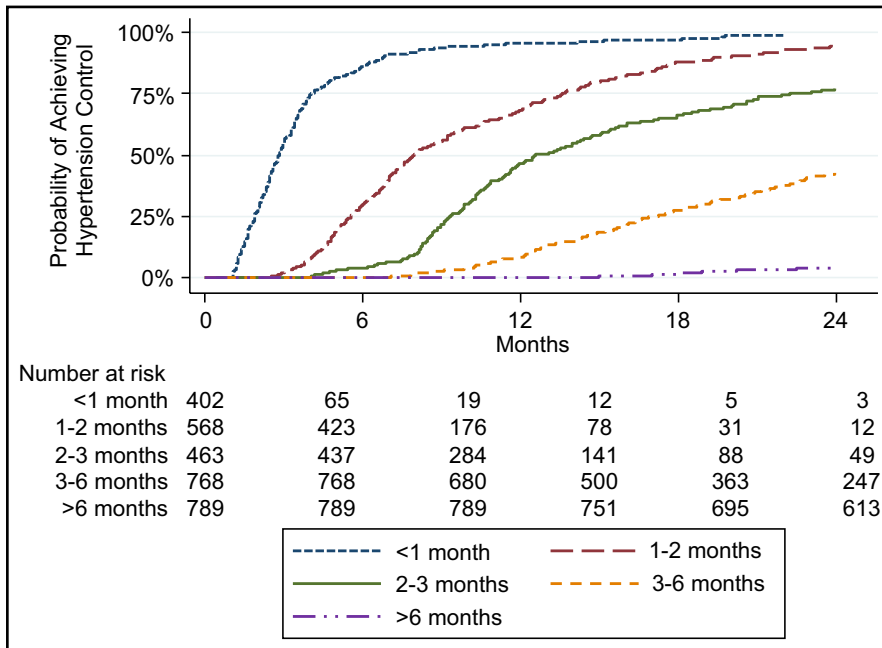


FIGURE 2 Probability of achieving hypertension control by encounter interval

(the initial electronic health record entry of an antihypertensive medication prescription).⁹ Trends demonstrated that young adults with shorter encounter intervals had lower antihypertensive medication initiation rates: <1-month encounter interval ($n = 83$, 21% prescribed medication), 1- to 2-month interval ($n = 150$, 26%), 2- to 3-month interval ($n = 135$, 29%), 3- to 6-month interval ($n = 209$, 27%), and >6-month interval ($n = 195$, 25%). Provider variables (age, sex, specialty) were not significant predictors for medication initiation.

4 | DISCUSSION

Our findings demonstrate significant differences in rates of hypertension control among young adults with incident hypertension according to their follow-up encounter interval. Young adults with a shorter encounter interval (<1 month) had higher rates of hypertension control compared with young adults with longer follow-up intervals. The encounter interval remained a significant predictor of time to hypertension control even after adjusting for patient and provider factors. Shorter return visit intervals have been associated with higher rates of hypertension control among middle-aged and older populations.¹² However, this study highlights that the return encounter interval is an independent contributor to hypertension control specifically among young adults and beyond mean annual clinic visits.

Young adults have persistently low hypertension control rates³⁰; however, there is a paucity of data on effective, sustainable approaches to address this concerning trend. Our findings demonstrate that shorter encounter intervals may be an effective tool for increasing rates of hypertension control among young adults. Interestingly, our data demonstrated that shorter encounter intervals were associated with lower antihypertensive medication initiation rates, likely underscoring the effectiveness of lifestyle modifications in young adults at

the initial stages of BP elevation. An alternative explanation is that during subsequent visits, some individuals no longer met criteria for hypertension (ie, regression to the mean); however, this is less likely given the serially elevated baseline BPs prior to cohort entry.

It is also imperative to highlight the relationship between an encounter interval (the time between visits) and the total number of provider visits. Although the encounter interval was an independent predictor of time to hypertension control, we observed a similar absolute number of primary care visits between the <1-month, 1- to 2-month, and 2- to 3-month intervals despite significant differences in hypertension control rates. Our findings that shorter encounter intervals lead to increased rates of hypertension control likely reflect visits with reinforcement of lifestyle modifications, and, if needed, timely initiation or titration of antihypertensive medication. In addition, early, more frequent follow-up likely engages young adults with their primary care team, which supports ongoing ambulatory encounters. Patients with 3- to 6-month and >6-month intervals had lower absolute numbers of primary care visits; for these intervals, a lower number of visits may contribute to lower hypertension control rates. Interestingly, young adults with longer encounter intervals had higher baseline systolic and diastolic BPs. This group was also in the lower ACG tertile, which may be associated with fewer provider-initiated return visits. Our data highlight that, given the high-risk features of this population (eg, high prevalence of obesity and comorbid conditions), close hypertension follow-up is indicated to achieve timely control.

Overall, our findings demonstrate that the optimal visit frequency is 1 month for young adults with uncontrolled hypertension, which supports prior recommendations in the JNC 7 guidelines.¹ Unfortunately, young adults may have difficulty in adhering to the recommended frequency as a result of visit copayments, childcare needs, school, and/or work schedules. Prior studies have suggested using telephone follow-up and team-based care to bridge follow-up

TABLE 2 HRs and 95% CIs of independent predictors for achieving hypertension control in patients aged 18 to 39 years (N = 2990)

Variable	Unadjusted HR	Unadjusted 95% CI	P value*	Adjusted HR	Adjusted 95% CI	P value*
Patient characteristics						
Encounter interval						
<1 mo (reference)		-	-	1.00	-	-
1–2 mo	0.25	(.22–.29)	<0.001	.24	(.18–.31)	<.001
2–3 mo	0.12	(.10–.13)	<0.001	.11	(.08–.14)	<.001
3–6 mo	0.04	(.03–.05)	<0.001	.04	(.03–.05)	<.001
>6 mo	0.008	(.007–.010)	<0.001	.008	(.005–.011)	<.001
Patient age						
Lowest age tertile (reference)			1.00	-	-	
Middle age tertile			1.10	(.94–1.29)	.25	
Highest age tertile			0.88	(.74–1.05)	.17	
Male sex			0.97	(.85–1.10)	.60	
Race/ethnicity ^a						
White (reference)			1.00	-	-	
Nonwhite			0.84	(.69–1.03)	.10	
Tobacco use						
Current tobacco use			0.82	(.68–.98)	.03	
Never/former tobacco use (reference)			1.00	-	-	
BMI, kg/m ²						
BMI <25 kg/m ² (reference)			1.00	-	-	
BMI 25–29 kg/m ²			0.90	(.73–1.12)	.35	
BMI ≥30 kg/m ²			0.81	(.68–.98)	.03	
On Medicaid ever ^b			0.96	(.79–1.17)	.69	
Baseline SBP tertiles						
Lowest SBP tertile (reference)			1.00	-	-	
Middle SBP tertile			0.71	(.60–.84)	<.001	
Highest SBP tertile			0.64	(.53–.76)	<.001	
Baseline DBP tertiles						
Lowest DBP tertile (reference)			1.00	-	-	
Middle DBP tertile			0.85	(.72–.99)	.04	
Highest DBP tertile			0.64	(.53–.76)	<.001	
Baseline comorbid conditions						
Hyperlipidemia			1.09	(.90–1.32)	.36	
Diabetes mellitus			1.19	(.88–1.59)	.26	
Anxiety and/or depression			0.90	(.77–1.06)	.20	
Low prevalence conditions ^c			1.06	(.88–1.28)	.52	
ACG ^d risk score						
Lowest ACG tertile (reference)			1.00	-	-	
Middle ACG tertile			1.10	(.92–1.33)	.30	
Highest ACG tertile			1.29	(1.04–1.60)	.02	

Abbreviations: BMI, body mass index; CI, confidence interval; DBP, diastolic blood pressure; HR, hazard ratio; SBP, systolic blood pressure.

*P value: Bonferroni's conservative correction was applied (Bolded P values are statistically significant at $P < .002$). Global P value for proportional hazards assumption: $P = .1687$.

^aNonwhite: black (5.6%), Hispanic/Latino (2.1%), Asian (1.9%), Native Hawaiian/Pacific Islander (0.4%), American Indian/Alaska Native (0.3%), and unknown (2.7%).

^bOn Medicaid at any point during the baseline or study period.

^cLow prevalence conditions include: chronic kidney disease, neurologic conditions, anemia, chronic pulmonary disease, thyroid disorders, rheumatologic disorders, and inflammatory bowel disease.

^dAdjusted Clinical Group (ACG) case-mix assessment system.

visits⁴⁶⁻⁴⁸ and support hypertension care delivery in this hard-to-reach population.

5 | STUDY STRENGTHS AND LIMITATIONS

The primary strength of this study was the ability to analyze a large sample of young adults with incident hypertension who received regular primary care in a large multispecialty group practice. However, the findings may not be generalizable to young adults without health-care access attributable to lack of insurance or other transitions. Another limitation is the use of data from a single healthcare system, which limits the generalizability of the findings; treatment patterns may differ across systems and regions. However, this healthcare system is one of the 10 largest physician practices in the United States, including over 300 primary care physicians and 43 primary care clinics. Moreover, the inclusion of numerous covariates including patient demographics, comorbidities, and utilization data with provider data improves the validity and clinical applicability of our study. The use of retrospective administrative data raises the potential for misclassification of diagnoses, lack of documentation in the electronic health record, and inability to measure medication persistence. However, validated algorithms were used to identify hypertension and other comorbidities. Finally, we had a small sample size of young adults with diabetes mellitus, which prohibited stratified analyses with lower treatment thresholds.

6 | CONCLUSIONS

Poor hypertension control rates among young adults underscores the critical need to develop effective interventions to improve hypertension control and reduce hypertension-related morbidity and mortality. Understanding the impact of timely follow-up and shorter encounter intervals on hypertension control rates among young adults provides healthcare providers, administrators, and policy makers an evidence-based target to improve the delivery of hypertension care.

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CONFLICT OF INTEREST

C. Bartels and H. Johnson have a clinical appointment with the academic group practice that has a financial interest in delivering care to the general population from which the study participants were drawn. Dr Bartels also receives grant funding from Independent Grants for Learning and Change (Pfizer). The remaining authors declare no conflicts of interest.

AUTHOR CONTRIBUTIONS

H. Johnson had full access to all of the data in the study and takes responsibility for the integrity of the data and accuracy of the data analysis. H. Johnson designed the study, performed the statistical analysis and interpretation of the data, and drafted the article. C. King, C. Bartels, E. Magnan, and J. Fink assisted in the interpretation of data, critical revision of the manuscript for important intellectual content, and provided final approval of the version to be published. M. Smith assisted with the design of the study, statistical analysis, interpretation of data, and critical article revisions, and provided final approval of the version to be published. All authors give the corresponding author (H. Johnson) permission to commit to all requirements for copyright transfer.

ORCID

Heather M. Johnson  <http://orcid.org/0000-0002-4916-3519>

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