

# Antihypertensive Prescribing Patterns for Adolescents With Primary Hypertension

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## KEY WORDS

hypertension, adolescents, primary care, specialty differences, antihypertensive prescribing

## ABBREVIATIONS

ACE—angiotensin converting enzyme inhibitor  
ARB—angiotensin receptor blocker  
BB— $\beta$ -blocker  
BP—blood pressure  
CI—confidence interval  
CVD—cardiovascular disease  
DIU—diuretic  
HTN—hypertension  
ICD-9-CM—*International Classification of Diseases, Ninth Revision, Clinical Modification*  
OR—odds ratio  
PCP—primary care physician  
Spec—subspecialist

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**WHAT'S KNOWN ON THIS SUBJECT:** Primary hypertension is a growing concern in adolescents due to its association with the obesity epidemic. Recent studies have examined underdetection and underdiagnosis of hypertension in adolescents but medical management of primary hypertension in adolescents is not well-described.



**WHAT THIS STUDY ADDS:** Our study describes patterns of antihypertensive prescribing for adolescents with primary hypertension including the use of monotherapy versus combination therapy by physicians of different specialties and factors associated with receipt of antihypertensive therapy over a multi-year period.

## abstract



**BACKGROUND:** Hypertension is an increasingly common problem in adolescents yet current medical management of primary hypertension in adolescents has not been well-described.

**METHODS:** We identified adolescents with primary hypertension by *International Classification of Diseases, Ninth Revision* codes and looked at prescription patterns chronologically for antihypertensive drug class prescribed and the specialty of prescribing physician. We also examined patient demographics and presence of obesity-related comorbidities.

**RESULTS:** During 2003–2008, there were 4296 adolescents with primary hypertension (HTN); 66% were boys; 73% were aged 11 to 14 years; 53% were black, 41% white, and 4% Hispanic; and 48% had obesity-related comorbidity. Twenty-three percent (977) received antihypertensive prescription. White subjects (odds ratio [OR]: 1.61; confidence interval [CI]: 1.39–1.88), older adolescents ( $\geq 15$  years, OR: 2.11; CI: 1.79–2.48), and those with comorbidity (OR: 1.57; CI: 1.36–1.82) were more likely to receive antihypertensive prescriptions controlling for gender and years of Medicaid eligibility in logistic regression. Angiotensin converting enzyme inhibitors were the most frequently prescribed monotherapy. Nearly two-thirds of adolescents received prescriptions from adult primary care physicians (PCPs) only. More than one-quarter of adolescents who received a prescription received combination therapy, which was most often prescribed by adult PCPs.

**CONCLUSIONS:** Adult PCPs were the leading prescribers of antihypertensives for adolescents with primary HTN. Race differences exist in physicians' prescribing of antihypertensives to adolescents with primary HTN. The choice of antihypertensives by physicians of different specialties warrants additional study to understand the underlying rationale for treatment decisions and to determine treatment effectiveness. *Pediatrics* 2012;129:e1–e8

There is growing concern about elevated blood pressure (BP) and hypertension (HTN) in adolescents because of its association with the obesity epidemic, which is estimated as affecting one-third of American adolescents.<sup>1–3</sup> Moreover, HTN in adults is a known risk factor for cardiovascular disease (CVD), one of the leading causes of morbidity and mortality in American adults.<sup>4</sup> Recent studies have examined issues of underdetection and underdiagnosis of HTN in adolescents.<sup>5,6</sup> However, current medical management of primary HTN in adolescents has not been well described.

Pediatric guidelines (2004) recommend initiating antihypertensive drug therapy in adolescents who have persistent HTN despite lifestyle modifications, using monotherapy from any of the 5 common antihypertensive drug classes: angiotensin converting enzyme inhibitors (ACEs), angiotensin receptor blockers (ARBs),  $\beta$ -blockers (BBs), calcium channel blockers, and diuretics (DIUs); importantly, there is no prioritization of drug choice.<sup>7</sup> Guidelines also recommend consideration of combination drugs if the desired BP goal is not achieved on monotherapy. It is unknown which antihypertensive medications are prescribed for treatment of primary HTN in adolescents and whether pharmacotherapy varies by the specialty of prescribing physician and/or patient characteristics such as demographics and presence of comorbidities.

The purpose of this study was to describe the use of antihypertensive pharmacotherapy to treat primary HTN in adolescents and the associated physician and patient characteristics. Our assumption was that subspecialty physicians, such as pediatric cardiologists and nephrologists, would most frequently prescribe antihypertensive medications to adolescents with primary HTN and that adolescents with

comorbidities, such as obesity and diabetes would more likely receive antihypertensive therapy compared with those without comorbidity.

## METHODS

### Study Design

We conducted longitudinal analysis of Michigan Medicaid outpatient claims and pharmacy data from 2003 through 2008 for adolescents aged 12 to 18 years. We identified adolescents with primary HTN by *International Classification of Diseases, Ninth Revision, Clinical Modification* (ICD-9-CM) codes and examined antihypertensive prescription patterns chronologically for antihypertensive drug class prescribed (if any) and the specialty of the prescribing physician. This study was approved by the Institutional Review Board of University of Michigan Medical School.

### Study Population

The sampling frame was adolescents aged 12 to 18 years on December 31, 2003, who were eligible for Michigan Medicaid for at least 3 of 6 years ( $\geq 11$  months per year) during the period 2003–2008. We included both fee-for-service and managed care Medicaid coverage and included those with dual Title V eligibility. We excluded years in which children had other insurance coverage.

We considered adolescents to have primary HTN if they had an outpatient clinic visit claim with an ICD-9-CM code for either HTN (401.X) or elevated BP without HTN (796.2).<sup>5</sup> We excluded adolescents who had  $\geq 1$  visits with an ICD-9-CM code for malignant HTN, pregnancy-related HTN, portal HTN, pulmonary HTN, glaucoma, and secondary HTN; we also excluded adolescents who had  $\geq 1$  visits with an ICD-9-CM code for common pediatric causes of secondary HTN such as renal disease, coarctation of aorta, hyperthyroidism, Cushing's syndrome, and

pheochromocytoma. A full list of exclusion codes is found in the Appendix. We also excluded adolescents who had any pharmacy claims for clonidine or guanfacine to focus on physician prescribing of 5 common antihypertensive drug classes recommended for treatment of pediatric HTN.

### Variables of Interest

Pharmacy claims for the duration of Medicaid eligibility were acquired; claims included National Drug Codes and prescriber identifiers. Companion data files were used to link prescriber identification numbers with physician specialty data; specialty was categorized as adult primary care physicians (PCPs; family physicians, general practitioners, internists, medicine-pediatrics), pediatric PCPs (general pediatricians), subspecialists (Specs; both adult and pediatric subspecialties including but not limited to cardiology, nephrology, emergency medicine, endocrinology, rheumatology), and unknown.

From this analytic file, we created the following variables:

- Receipt of  $\geq 1$  prescription for an antihypertensive drug during the study period;
- Class of antihypertensive prescription: each prescription was categorized as 1 of 5 classes recommended for pediatrics;
- Antihypertensive monotherapy versus combination therapy: (1) monotherapy was defined as having prescription claims for only 1 antihypertensive medication per day. Adolescents who were switched from 1 antihypertensive single drug to another were categorized according to the drug class of the last antihypertensive prescription claim, to allow mutually exclusive groups. (2) Combination therapy was defined as prescription claims for 2 drug classes on the same or  $\pm 1$  day; a repetitive pattern of

prescription claims for 2 drug classes; or  $\geq 1$  prescription claim for a combination antihypertensive medication (ie, 1 medication formulated with 2 antihypertensive drugs, such as Lotensin HCT). Adolescents who received combination therapy at any time during the study period were classified as having combination therapy, even if they had periods of monotherapy;

- Mean and median number of antihypertensive prescriptions filled per year of Medicaid eligibility;
- Drug class of first antihypertensive prescription;
- Age at first antihypertensive prescription;
- Time between first monotherapy prescription and first combination therapy prescription;
- Combination therapy as 1 pill versus multiple drugs;
- Duration of Medicaid eligibility (3 years vs 4–6 years); and
- Prescriber specialty across all antihypertensive prescriptions during the study period, categorized as adult PCPs only, general pediatric PCPs only, Spec only, both PCP and Spec, both adult PCP and pediatric PCP, and unknown.

### Independent Variables

Demographic variables included age at start of Medicaid eligibility during 2003–2008 categorized as younger (11–14 years) versus older adolescents (15–19 years); race categorized as white, black, Hispanic, and other/unknown; and gender. Given that the sampling frame was age 12–18 years on December 31, 2003, it was possible for adolescents who were aged 11 years or 19 years at start of their Medicaid eligibility to be included in the study. Adolescents could have had a diagnosis of HTN at any point during the 3+ years of Medicaid eligibility from 2003 to 2008.

Thus, age at first HTN diagnosis does not necessarily equal age at start of Medicaid eligibility. Presence of obesity-related comorbidities was defined as having  $\geq 1$  visits with an ICD-9-CM code for obesity, hyperlipidemia, type 2 diabetes mellitus, or metabolic syndrome.

### Statistical Analysis

Descriptive analyses included simple counts and proportions. We used  $\chi^2$  tests to assess associations between receipt of antihypertensive prescription and demographic characteristics, and choice of antihypertensive drug class prescribed and prescribing physician specialty. We performed multivariate logistic regression to evaluate the associations between demographics and receipt of antihypertensive prescription, among all adolescents with primary HTN. We also performed multivariate logistic regression to evaluate the associations among demographics, prescribing physician specialty, and receipt of combination antihypertensive therapy among the subset of adolescents who received at least 1 antihypertensive prescription. *P* values  $\leq 0.05$  were considered statistically significant. All analyses were performed using SAS version 9.2.

### RESULTS

On December 31, 2003, there were 416 878 adolescents aged 12 to 18 years enrolled in Michigan Medicaid program, of which 155 913 had at least 3 years of enrollment ( $\geq 11$  months of Medicaid eligibility and no other insurance for each study year) during 2003–2008. From this, we identified 8549 adolescents with a diagnosis of primary HTN at an outpatient visit then excluded those with secondary causes of HTN and receipt of clonidine or guanfacine prescription, resulting in our final study sample of 4296 adolescents.

### Study Sample Characteristics

For the 4296 adolescents who met eligibility criteria, two-thirds were boys;

73% were aged 11 to 14 years at start of Medicaid eligibility; and 53% were black, 41% white, and 4% Hispanic (Table 1). The majority of our study sample ( $n = 3806$ ) had a diagnosis of HTN (401.×), and 490 adolescents had elevated BP without HTN (796.2) with no difference in demographics. Our sample demographics ( $n = 4296$ ) were also similar to the Medicaid population in general with the exception of gender; one-third of our sample were girls, whereas gender was more evenly distributed in the general Medicaid population. Nearly half had an obesity-related comorbidity (48%). One-third of adolescents had 6 years of Medicaid eligibility, with 80% enrolled during the first year (2003) of the study period (Table 1).

During the study period, 23% of adolescents in our sample ( $n = 977$ ) received at least 1 antihypertensive prescription. A quarter of the 3806 with HTN diagnosis (401.×) received antihypertensive

**TABLE 1** Demographic Characteristics of Adolescents with  $\geq 3$  Years of Medicaid Eligibility and Primary HTN Diagnosis During 2003–2008 ( $N = 4296$ )

|                                     | Overall, <i>n</i> (%) |
|-------------------------------------|-----------------------|
| Gender                              |                       |
| Male                                | 2828 (66)             |
| Female                              | 1468 (34)             |
| Race                                |                       |
| White                               | 1757 (41)             |
| Black                               | 2279 (53)             |
| Hispanic                            | 164 (4)               |
| Other/unknown                       | 96 (2)                |
| Obesity-related comorbidity         |                       |
| Yes                                 | 2063 (48)             |
| No                                  | 2233 (52)             |
| Age at first eligibility, y         |                       |
| 11–14                               | 3126 (73)             |
| 15–19                               | 1170 (27)             |
| Duration of Medicaid eligibility, y |                       |
| 3                                   | 880 (21)              |
| 4                                   | 944 (22)              |
| 5                                   | 999 (23)              |
| 6                                   | 1473 (34)             |
| First y of eligibility              |                       |
| 2003                                | 3441 (80)             |
| 2004–2006                           | 855 (20)              |
| Age at first HTN diagnosis, y       |                       |
| 11–14                               | 692 (16)              |
| $\geq 15$                           | 3604 (84)             |

prescriptions compared with 5% of the 490 with elevated BP without HTN (796.2). Thus, adolescents with elevated BP without HTN did not significantly affect the overall number of adolescents who received antihypertensive prescriptions in our study. Characteristics associated with adolescents who received antihypertensive prescriptions are presented in Table 2. Older and white adolescents were more likely than younger and black adolescents to receive an antihypertensive prescription. Adolescents with obesity comorbidity also were more likely to receive an antihypertensive prescription.

Mean and median antihypertensive prescriptions filled per year of Medicaid eligibility were 2.4 and 1.2, respectively. This did not vary significantly by gender; however, white subjects (mean 2.9, median 1.4) and older adolescents (mean 3.3, median 1.5) had higher mean and median prescriptions per year of eligibility compared with black subjects

(mean 1.9, median 0.8) and younger adolescents (mean 1.9, median 0.8;  $P < .0001$ ).

### Antihypertensive Prescriptions for Adolescents With Primary HTN ( $n = 977$ )

Overall, mean and median age at first antihypertensive prescription was similar at 16.9 and 17 years, respectively, and did not vary significantly by gender, race, or presence of obesity-related comorbidity. Among adolescents who received antihypertensive prescription, 86% ( $n = 839$ ) initially received monotherapy; 72% ( $n = 701$ ) continued with monotherapy only during the study period, with ACE as the most frequently prescribed drug class (Table 3). Twelve percent of the monotherapy-only group was switched from the initial antihypertensive monotherapy to a different monotherapy drug class during the study period, most often from diuretics and BB to ACE.

Combination antihypertensive therapy was prescribed at some point in the study period for 28% ( $n = 276$ ) of adolescents who received any antihypertensive prescription. Of the 276 adolescents who ever received combination therapy, 50% ( $n = 138$ ) had combination antihypertensives as the first prescription identified during the study period, 30% ( $n = 84$ ) received combination therapy within the first year of receiving monotherapy, and 20% ( $n = 54$ ) received combination therapy  $\geq 1$  to 6 years after receiving monotherapy. The 3 most commonly prescribed drug combinations were ACE-DIU, DIU-DIU, and BB-DIU combinations. Among adolescents who ever received combination therapy, 68% ( $n = 188$ ) were prescribed 1-pill combination drugs (Table 3).

### Physician Specialty ( $n = 977$ )

Nearly two-thirds of adolescents with primary HTN with antihypertensive prescription received prescriptions from adult PCPs only (Table 3). Ten percent of adolescents received their antihypertensive prescription only from Specs, and 5% received their antihypertensive prescription only from pediatric PCPs.

Adult PCPs (62%) were also leading prescribers of combination antihypertensives, whereas Specs (7%) and pediatric PCPs (3%) prescribed fewer combination antihypertensives (Table 3). Adolescents who received antihypertensive prescriptions from physicians of multiple specialties during the study period were more likely to receive combination therapy versus monotherapy (42% from both PCPs and Specs,  $n = 57$ ; 34% from both adult PCPs and pediatric PCPs,  $n = 11$ ) compared with those receiving prescriptions from adult PCPs only (28%,  $n = 172$ ), Specs only (20%,  $n = 19$ ), and pediatric PCPs only (16%,  $n = 7$ ;  $P < .0001$ ; Table 3).

Among the subset of adolescents receiving combination therapy, those

**TABLE 2** Characteristics Associated With Receipt of Antihypertensive Prescription During 2003–2008

|                                     | Adolescents With Primary HTN Who Received Antihypertensive Prescription, % | $\chi^2$ P Value |
|-------------------------------------|--|------------------|
| Overall ( $n = 4296$ )              | 23   |                  |
| Gender                              |  | .1706            |
| Male ( $n = 2828$ )                 | 23   |                  |
| Female ( $n = 1468$ )               | 22   |                  |
| Race                                |  | <.0001           |
| White ( $n = 1757$ )                | 28   |                  |
| Black ( $n = 2279$ )                | 19   |                  |
| Hispanic ( $n = 164$ )              | 25   |                  |
| Other/unknown ( $n = 96$ )          | 17   |                  |
| Obesity-related comorbidity         |  | <.0001           |
| Yes ( $n = 2063$ )                  | 27   |                  |
| No ( $n = 2233$ )                   | 19   |                  |
| Age at first eligibility, y         |  | <.0001           |
| 11–14 ( $n = 3126$ )                | 19   |                  |
| 15–19 ( $n = 1170$ )                | 33   |                  |
| Duration of Medicaid eligibility, y |  | .0158            |
| 3 ( $n = 880$ )                     | 26   |                  |
| 4 ( $n = 944$ )                     | 23   |                  |
| 5 ( $n = 999$ )                     | 22   |                  |
| 6 ( $n = 1473$ )                    | 21   |                  |
| First y of eligibility              |  | .7459            |
| 2003 ( $n = 3441$ )                 | 23   |                  |
| 2004–2006 ( $n = 855$ )             | 23   |                  |
| Age at first HTN diagnosis, y       |  | .0067            |
| 11–14 ( $n = 692$ )                 | 19   |                  |
| $\geq 15$ ( $n = 3604$ )            | 24   |                  |

**TABLE 3** Medicaid Adolescents With Primary HTN and Antihypertensive Prescription, by Drug Class and Prescribing Physician (*n* = 977)

|                                | ACE       | ARB    | BB        | CCB     | DIU       | Combo     |                | Total (%) |
|--------------------------------|-----------|--------|-----------|---------|-----------|-----------|----------------|-----------|
|                                |           |        |           |         |           | One Drug  | Multiple Drugs |           |
| Adult PCP only                 | 164       | 2      | 114       | 46      | 118       | 127       | 45             | 616 (63)  |
| Pediatric PCP only             | 17        | 0      | 2         | 6       | 13        | 6         | 1              | 45 (5)    |
| Spec only                      | 27        | 0      | 23        | 4       | 23        | 12        | 7              | 96 (10)   |
| Both PCP + Spec                | 33        | 2      | 16        | 11      | 16        | 33        | 24             | 135 (14)  |
| Both adult PCP + pediatric PCP | 8         | 2      | 2         | 2       | 7         | 5         | 6              | 32 (3)    |
| Unknown                        | 9         | 0      | 8         | 8       | 18        | 5         | 5              | 53 (5)    |
| Total                          | 258 (26%) | 6 (1%) | 165 (17%) | 77 (8%) | 195 (20%) | 276 (28%) |                | 977       |

CCB, calcium channel blockers; Combo, combination antihypertensive drugs.  $P \leq 0.001$ .

who received prescriptions from physicians of multiple specialties during the study period (both adult PCP + pediatric PCP and both PCP + Spec groups) were also more likely to receive combination therapy as multiple drugs than as 1 pill compared with those receiving combination therapy from physicians of single specialty with the exception of unknowns (Table 3). Prescription of combination therapy as 1 pill versus multiple drugs did not vary significantly by race, age, and gender.

### Multivariate Logistic Regression Analysis

Among all adolescents with primary HTN, receipt of antihypertensive prescriptions was significantly associated with age, race, and presence of obesity-related comorbidity in our multivariate logistic regression model (Table 4). Controlling for patient gender and years of Medicaid eligibility, older adolescents, those with obesity-related comorbidities, and white subjects were more likely to receive antihypertensive prescriptions

compared with younger adolescents, those without obesity comorbidity, and black subjects.

Among the subset of adolescents who received antihypertensive prescriptions, receipt of combination therapy was significantly associated with age, gender, race, and prescribing physician specialty in our multivariate logistic regression model (Table 5). Controlling for obesity comorbidity and years of Medicaid eligibility, older adolescents, girls, black subjects, and adolescents who received prescriptions from both PCPs and Specs were more likely to receive combination therapy compared with younger adolescents, boys, white subjects, and adolescents who received prescriptions only from Specs.

### DISCUSSION

Our study describes for the first time the proportion of adolescents with primary HTN who receive antihypertensive prescriptions over a multiyear period and demographic characteristics associated with receipt of

antihypertensive prescriptions. Additionally, our study provides the first look at patterns of antihypertensive prescribing for adolescents with primary HTN including the use of monotherapy versus combination therapy by physicians of different specialties and factors associated with receipt of combination antihypertensive therapy.

In our study, white adolescents were significantly more likely to receive antihypertensive prescriptions compared with black subjects when controlling for obesity-related comorbidity, patient age, and gender, as well as years of Medicaid eligibility. Previous studies of US adults have documented race disparities in HTN prevalence with non-Hispanic black subjects having higher risk for HTN, CVD, and stroke compared with non-Hispanic white subjects and Mexican-American subjects.<sup>8</sup> Our study suggests that race differences exist in physicians' prescribing of antihypertensives to adolescents with primary HTN. Importantly, we also found that black adolescents were more likely to receive combination therapy compared with white subjects when controlling for other patient characteristics and specialty of prescribing physician.

Taken together, these findings may reflect potential undertreatment or delay in treatment of HTN in black subjects. Increased use of combination therapy in black subjects may also reflect more aggressive BP control given that black adolescents with primary HTN have

**TABLE 4** Multivariate Logistic Regression of Patient Characteristics Associated With Receipt of Antihypertensive Prescription for Medicaid Adolescents With Primary HTN (*N* = 4296)

|   | OR   | <i>P</i> Value | 95% CI    |
|---|------|----------------|-----------|
| Male (ref = female)                                 | 1.10 | .2379          | 0.94–1.29 |
| Age at first eligibility<br>15–19 y (ref = 11–14 y) | 2.11 | <.0001         | 1.79–2.48 |
| White (ref = black)                                 | 1.61 | <.0001         | 1.39–1.88 |
| Hispanic (ref = black)                              | 1.35 | .1182          | 0.93–1.96 |
| Other/unknown (ref = black)                         | 0.88 | .6635          | 0.51–1.54 |
| Has obesity comorbidity (ref = no comorbidity)      | 1.57 | <.0001         | 1.35–1.82 |
| 4–6 y of Medicaid eligibility (ref = 3 y)           | 1.08 | .5680          | 0.89–1.30 |

ref, reference.

**TABLE 5** Multivariate Logistic Regression of Patient Factors and Prescribing Physician Specialty Associated With Receipt of Combination Antihypertensive Prescription for Medicaid Adolescents With Primary HTN (*n* = 977)

|  | OR   | <i>P</i> Value | 95% CI    |
|--|------|----------------|-----------|
| Female (ref = male)                              | 1.38 | .0363          | 1.02–1.86 |
| Age at first eligibility 15–19 y (ref = 11–14 y) | 1.50 | .0104          | 1.10–2.04 |
| Black (ref = white)                              | 1.39 | .0280          | 1.04–1.88 |
| Hispanic (ref = white)                           | 0.88 | .7507          | 0.40–1.92 |
| Other/unknown (ref = white)                      | 1.61 | .3997          | 0.53–4.87 |
| Has obesity comorbidity (ref = no comorbidity)   | 1.05 | .7607          | 0.78–1.40 |
| 4–6 y of Medicaid eligibility (ref = 3 y)        | 1.14 | .4792          | 0.79–1.64 |
| Adult PCP only (ref = Spec only)                 | 1.56 | .1075          | 0.91–2.66 |
| Pediatric PCP only (ref = Spec only)             | 0.76 | .5700          | 0.29–1.97 |
| Both PCP + Spec (ref = Spec only)                | 2.93 | .0006          | 1.58–5.41 |
| Both adult PCP + pediatric PCP (ref = Spec only) | 2.14 | .0961          | 0.87–5.22 |
| Unknown (ref = Spec only)                        | 0.91 | .8208          | 0.38–2.14 |

ref, reference.

higher risk of CVD compared with non-black adolescents.<sup>9</sup> Previous studies of adults with HTN have shown black subjects to be less responsive to monotherapy and thus often requiring treatment with drugs from 2 or more antihypertensive drug classes.<sup>10</sup> Additional study of physician decision making, as well as clinical outcomes, is warranted to better understand the racial patterns observed in this study.

Our study also found that older adolescents and those with obesity-related comorbidities were more likely to receive antihypertensive prescriptions compared with younger adolescents and those without comorbidity when controlling for patient gender and race. Older adolescents were also more likely to receive combination therapy. This is consistent with previous work<sup>11</sup> and with clinical experience; older adolescents are more likely to have longer duration of disease, higher severity of disease, and/or episodes of treatment failures. Moreover, guidelines recommend pharmacotherapy to treat HTN in adolescents with comorbid conditions; thus, our findings are consistent with treatment recommendations according to national guidelines.<sup>7</sup>

Antihypertensive medications were prescribed most frequently by adult PCPs in our study. Elevated BP values indicating hypertensive range for adolescents

(eg, 122/80 for a 12-year-old boy at the lowest height quartile) begin to resemble pre-HTN (120/80) for adults, indicating increased risk of heart disease and stroke.<sup>4,7,12</sup> Thus, it is likely that adult PCPs familiar with management of HTN in adults have improved awareness and detection of abnormally elevated BP values requiring pharmacotherapy in adolescents. Moreover, adult PCPs, who often initiate and manage pharmacotherapy in treatment of HTN in adults, are likely as comfortable prescribing antihypertensive medications to adolescents as adults. In contrast, our study found that general pediatric PCPs and Specs were less frequent prescribers of antihypertensive medications for adolescents. A previous study suggests that only 7% of general pediatric PCPs initiate pharmacologic treatment of adolescents with primary HTN,<sup>13</sup> and it seems plausible that lack of familiarity with antihypertensive medications may play a role in this low rate. In addition, we have previously described pediatric cardiologists' and nephrologists' reluctance to initiate recommended antihypertensive pharmacotherapy in children with primary HTN.<sup>14</sup> Additional studies are needed to elucidate the underlying factors related to prescribing of antihypertensive pharmacotherapy in adolescents with primary HTN.

The use of combination antihypertensive pharmacotherapy suggests increased severity of illness where optimal BP control cannot be achieved on monotherapy. In our study, more than a quarter of Medicaid adolescents with primary HTN who received antihypertensive prescriptions were prescribed combination therapy. Importantly, we found that adolescents receiving combination therapy from physicians of multiple specialties during the study period received it more often in the form of multiple drugs that raise questions of medical comanagement and whether the use of multiple antihypertensives is coordinated between prescribers of different specialties. One rationale for prescribing multiple-drug combination therapy is cost; 4 of 5 recommended monotherapy drug classes have generic options available, whereas combination pills are relatively more new without generic options.<sup>15</sup> However, it is unknown whether there are differences in patient outcomes related to drug safety and efficacy using antihypertensive combination therapy prescribed as combination pill versus multiple drugs in adolescents with HTN. Further study is needed to evaluate treatment decisions and patient outcomes regarding the use and choice of different forms of combination therapy (1 pill vs multiple drugs) in adolescents with primary HTN by physicians of different specialty training.

## LIMITATIONS

Our findings should be interpreted with these limitations. First, our study population was adolescents enrolled in the Michigan Medicaid program, which has potential implications for generalizability of our results. Second, limitations of pharmacy claims analysis suggest prescription claims that were filled, which may potentially differ from utilization. Third, we examined prescription claims at the level of drug class, not individual drugs. We were

unable to determine whether maximal dose of monotherapy was achieved before adolescents were transitioned to combination therapy, if any. Fourth, formulary restrictions could potentially affect physician prescribing of newer antihypertensive medications such as ARBs. However, we had previously demonstrated that the Michigan Medicaid program offered more ARBs, BBs, and calcium channel blockers as preferred drugs when compared with a private insurance plan during a similar time period.<sup>15</sup> Finally, we acknowledge left-

censoring issue where we cannot evaluate antihypertensive prescriptions prescribed before 2003.

## CONCLUSIONS

Adult PCPs were leading prescribers of antihypertensive medications for adolescents with primary HTN. Race differences exist in physicians' prescribing of antihypertensives to adolescents with primary HTN; white adolescents are more likely to receive antihypertensives compared with black subjects. The

choice of antihypertensive medications by physicians of different specialties warrants additional study to understand the underlying rationale for those decisions and to determine treatment effectiveness.

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**APPENDIX** ICD-9-CM Codes for Study Inclusion and Exclusion Criteria

|  | ICD-9-CM Diagnosis Codes   |
|--|--|
| <b>Inclusions</b>  |  |
| Primary HTN  | 401x, 796.2  |
| <b>Exclusions</b>  |  |
| Malignant HTN  | 4010   |
| Pregnancy  | 630x–679x, V22x–V24x, V26x, 761x–763x, 767x, 768x, 760.0, 760.1, 760.3 |
| Portal HTN   | 452x, 570x   |
| Pulmonary HTN  | 415x– 417x   |
| Glaucoma   | 365x   |
| Secondary HTN  | 402x– 405x   |
| <b>Common causes of pediatric secondary HTN</b>                    |  |
| Congenital anomalies   | 753x, 747.1, 758.6   |
| Diseases of the circulatory system                                 | 444x, 446x, 447x, 453.3  |
| Diseases of the genitourinary system                               | 580x–594x  |
| Diseases of the musculoskeletal system and connective tissue       | 710x, 720x   |
| Diseases of the nervous system and sense organs                    | 325x, 326x, 327.2, 3240, 3249, 3482                                    |
| Endocrine, nutritional, and metabolic diseases; immunity disorders | 240x–246x, 252x, 253x, 255x, 256.4                                     |
| Neoplasms  | 189x, 191x, 193x, 194x, 223x, 225x–227x, 237                           |
| Polycythemia   | 776.4  |
| Chronic respiratory disease arising in the perinatal period        | 770.7  |

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