Failure to Confirm High Blood Pressures in Pediatric Care - Quantifying the risks of misclassification

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Abbreviations: BMI – body mass index; EMR – electronic medical record; KPSC – Kaiser Permanente Southern California

ABSTRACT

Pediatric practice guidelines call for repeating an elevated office blood pressure (BP) at the same visit, but there are few data available to support this recommendation. We compared the visit results in children 3-17 years with a BP reading ≥95th percentile (n=186,732) based on the initial BP and the mean of two BP readings, using electronic medical records from 2012-2015. Failure to repeat an initial BP reading ≥95th percentile would lead to a false 'hypertensive' visit result in 54.1% of children who would require follow-up visits. After an initial visit result indicating hypertension, hypertension stage I or stage II was sustained in 2.3% and 11.3% of youth during their next visits, respectively. In conclusion, only approximately half of the pediatric patients would be correctly classified based on their initial BP. The recommendation to repeat high BP during the same visit needs to be emphasized because it saves unnecessary follow-up visits.

INTRODUCTION

High blood pressure is a major contributing risk factor for heart failure, heart attack, stroke, and chronic kidney disease and accounts for an estimated 18% of cardiovascular deaths in the U.S.[1] High blood pressure is not limited to adults. It is estimated that 4-5% of youth have hypertension, and another 13-18% of youth have prehypertension.[2-8] Children with elevated blood pressure are 2-3 times more likely to develop essential hypertension in young adulthood.[9] About 30-40% of youth with sustained hypertension show early signs of end-organ damage.[10, 11] Youth with cardiovascular risk developing early in life will face higher rates of cardiovascular morbidity and early death.[12] Therefore, screening for high blood pressure in asymptomatic youth is recommended as an important strategy for early diagnosis and treatment of hypertension to prevent cardiovascular disease.[13-19]

While routine medical visits offer a good opportunity to screen for high blood pressure in asymptomatic youth,[19] the adherence to current blood pressure screening guidelines is poor. Nationally representative data have shown that blood pressure is not measured in two-thirds of all pediatric visits, and one-third of pediatric preventive visits.[20] When blood pressure is measured, hypertension is often overlooked and under-diagnosed in pediatric populations until they transition to adult care.[21, 22]

Initial blood pressure readings can be high for various reasons including measurement error. Hence, blood pressure readings should be repeated during the same visit and the mean of blood pressure readings used as the visit result.[19] Repeating a high blood pressure during the same visit can prevent misclassification of a patient's visit result. This has implications for clinical practice because it is recommended that follow-up visits should be scheduled after a visit with a blood pressure ≥95th percentile to confirm or rule out hypertension. Misclassification of a patient's visit result as hypertensive may result in unnecessary follow-up visits which are a

burden for both, the patient and the health care system. However, studies are needed to quantify the magnitude of misclassification arising from the failure to repeat an initial high blood pressure reading.

To estimate the benefit of adhering to standardized protocols for blood pressure screening as recommended by the American Academy of Pediatrics and others,[15-19] we assessed the misclassification of pediatric patients as hypertensive based on an initial blood pressure reading which could be avoided by a repeated reading during the same visit. The classification of an individual's blood pressure as normotensive or hypertensive during the same visit was assessed based on 1) the initial blood pressure, 2) the mean of two blood pressure readings, and 3) the lower of two blood pressure readings. We also examined the occurrence of follow-up visits after an initial office visit with any hypertensive blood pressure and the proportion of youth with sustained hypertension if follow-up visits were completed as recommended by the American Academy of Pediatrics (AAP) and others.[15-19]

PATIENTS AND METHODS

Study Setting and Population

The Kaiser Permanente Southern California (KPSC) Children's Health Study includes children and adolescents who are actively enrolled in a KPSC health plan in 2007 or later. It is an ongoing cohort study that continuously enrolls new patients reaching the target age range or joining the health plan.[23] In 2010, KPSC members represented approximately 16.2% of the total coverage area population.[24] The cohort follow-up is conducted through passive surveillance of clinical care information using an electronic medical record (EMR) system. All administrative and clinical data are linked through a unique medical record number and include membership information, medical encounters, and other health care information. A detailed description of the cohort design and measurement protocol was published elsewhere.[23]

The analytic population of the present study was comprised of a subpopulation of the KPSC Children's Health Study. During the study period, we identified 826,648 youth between the ages of 3 and 17 who were KPSC members between January 1, 2012 and December 31, 2015, and had a medical encounter with at least one blood pressure reading, and valid height. We excluded youth who were pregnant (n=1,696) or whose medical record indicated fever (n=65,240) when blood pressure was measured. We also excluded youth with a pre-existing diagnosis of hypertension (n=2,231) and chronic conditions known to significantly affect blood pressure (n = 1,686), such as growth hormone deficiency or overproduction, aortic coarctation, chronic renal disease, congenital adrenal hyperplasia, Cushing syndrome, hyperaldosteronism, and/or hyperthyroidism.[25] Out of the remaining cohort of 755,795 youth, we identified 186,732 (24.7%) with at least one blood pressure reading ≥95th percentile for sex, age, and height during the four-year study period who were used as the final analytical cohort. The study protocol was reviewed and approved by the KPSC Institutional Review Board.

Body weight and height

Body weight and height were routinely measured and extracted from the EMR. Definitions for overweight and obesity in youth at the first visit with high blood pressure are based on the sex-specific body mass index (BMI)-for-age growth charts developed by the Centers for Disease Control and Prevention (CDC).[26] Overweight was defined as BMI-for-age ≥85th and <95th percentile (or BMI ≥25 kg/m^2), obesity as ≥95th percentile (or BMI ≥30 kg/m^2) and severe obesity as BMI-for-age ≥1.2 × 95th percentile (or BMI ≥35 kg/m^2).[27, 28]

Race and ethnicity

We obtained race and ethnicity information from health plan administrative records and birth records. We categorized race/ethnicity as non-Hispanic White, Hispanic (regardless of race), African American, Asian or Pacific Islander, and other or unknown race/ethnicity.

Socioeconomic Status

As individual level education and household income were not available through EMRs, neighborhood education and neighborhood household income at the first visit with high blood pressure were used to indicate socioeconomic status. These population level indicators were estimated by geocoding cohort members' addresses to 2010 US census block data.[29] We also used insurance through government health care assistance programs such as Medicaid, as an additional proxy for socioeconomic status.

Blood Pressure Screening and Classification

Blood pressure was measured routinely at the beginning of almost every outpatient medical visit, as described in detail elsewhere.[30] Nurses and medical assistants were trained according to guidelines of the American Association of Critical Care Nurses for pediatric care.[31] Digital devices (Welch Allyn Connex series, Welch Allyn Inc., Skaneateles Falls, NY) are the preferred blood pressure measurement devices at KPSC. However, it is possible that in some cases, a wall-mounted aneroid sphygmomanometer (Welch Allyn Inc., Skaneateles Falls, NY) was used instead of the preferred device. Medical staff were trained to ensure that the bladder inside the cuff encircles 80% to 100% of the circumference of the right arm according to standard recommendations.[31] A full range of different cuff sizes were available at the locations where patient blood pressure was taken. All staff members who measure blood pressure as part of their daily job functions are certified in blood pressure measurement during their initial staff orientation and recertified annually. Blood pressure readings are manually entered into the EMR system. Blood pressure is automatically translated into blood pressure percentiles and available

together with blood pressure history of the previous 2 visits in the progress notes. However, no alerts were used to inform if a blood pressure should be considered elevated and no best practice recommendations were provided during the study period on recommended follow-up and/or treatment.

Blood pressure readings for all outpatient medical encounters were extracted from the EMR. We classified blood pressure using the recommendations of the Fourth Report On the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents of the National High Blood Pressure Education Program (NHBPEP).[15, 19] Depending on sex, age, and height, blood pressure was defined as hypertensive stage 1 if it was ≥95th percentile but <99th percentile plus 5 mmHg; and hypertensive stage 2 if ≥99th percentile plus 5 mmHg.

Study Outcomes

The primary study outcome was the misclassification of the final visit outcome after an initial blood pressure reading ≥95th percentile for sex, age, and height during outpatient visits (n=186,732 youth). Using the mean of two consecutive blood pressures during an outpatient medical visit as gold standard,[15] we classified an individual's visit result as correct, false positive high blood pressure (defined as blood pressure status higher than correct), false negative (defined as blood pressure status lower than correct), or unknown (if initial blood pressure was not repeated, n=18,172) compared to an assessment based on the initial blood pressure. Similarly, we examined the classification of an individual's visit result as correct, false positive, or false negative if the lower of two blood pressure readings would be used compared to the initial reading. Among youth who were not classified as unknown during their initial visit (i.e. had a repeated blood pressure reading), the secondary study outcome was sustained hypertension defined as a total of three consecutive visits with a blood pressure ≥95th percentile for sex, age, and height (n=168,560). These youths were classified as sustained if they had any three

consecutive visits with a blood pressure ≥95th percentile. If all three blood pressures were ≥95th percentile but <99th percentile plus 5 mmHg, then sustained high blood pressure was classified as hypertension stage I. If any one blood pressure was ≥99th percentile plus 5 mmHg, then sustained high blood pressure was classified as hypertension stage II. Other youth were classified as either, 'not sustained', or unknown (if no or incomplete follow-up occurred).

Statistical Analysis

Summary statistics were calculated for sociodemographic characteristics. To investigate the relationship between sociodemographic characteristics (sex, age, race, and baseline weight class) and the repetition of blood pressure measurement, log binomial models from the SAS procedure GENMOD were used. Crude and adjusted relative risk (RR) and confidence intervals (CIs) are reported. Models were adjusted for all other sociodemographic characteristics listed above. After an initial high blood pressure ≥95th percentile for sex, age, and height, the follow-up was classified as completed if (1) one follow-up visit occurred with a blood pressure <95th percentile or (2) two follow-up visits occurred with a blood pressure ≥95th percentile, or 3) one follow-up visits occurred with a blood pressure ≥95th percentile and one <95th percentile.[15-19] Log binomial models were used to describe the association between patient characteristics and completion of recommended follow-up. All analyses were performed using SAS statistical software version 9.3 (SAS Institute Inc, Cary, NC).

RESULTS

Study population characteristics

Out of 755,795 youth between 3-17 years of age, 186,732 youth (24.7%) had a first blood pressure reading ≥95th percentile for sex, age, and height between January 1, 2012 and December 31, 2015. The majority of youth was Hispanic (52.4%) and had normal body weight (51.3%). About 26.5% of youth received health care services under a state subsidized health

plan such as MediCal. Among 186,732 youth with high blood pressure, 167,402 (89.6%) of youth had an initial blood pressure ≥95th percentile indicating hypertension stage I and 19,330 (10.4%) ≥99th + 5mm Hg percentile indicating hypertension stage II (**Table 1**). A repetition of blood pressure within the same visit was documented in the EMR for 18.3% of visits indicating hypertension stage I and 50.9% indicating hypertension stage II ($p < 0.001$). In crude analysis, a high blood pressure reading ≥95th percentile was more likely to be repeated during the same visit if the patient was male, older, or overweight to obese, Asian, or Hispanic. After multivariable adjustment, the likelihood for a repeated reading after an initial blood pressure ≥95th percentile was no longer significant for Hispanic youth. After multivariable adjustment, a high blood pressure reading ≥99th + 5mm Hg percentile was more likely to be repeated during the same visit if the patient was older, and less likely if the patient was Asian. The presence of obesity was not associated with the likelihood for a repeated blood pressure after an initial blood pressure reading ≥99th + 5mm Hg percentile.

Hypertension stage I

In youth for which the initial high blood pressure percentile was repeated during their visit (n=30,565), 51.2% of youth with an initial blood pressure ≥95th percentile had a mean of two consecutive blood pressure <95th percentile and were false positive results; these patients would be required to schedule potentially unnecessary follow-up appointments if the initial blood pressure reading would not have been repeated (**Figure 1**). Only 48.2% of youth also had a mean blood pressure ≥95th percentile. Another 1.2% of youth had a mean blood pressure ≥95th percentile but an initial blood pressure reading <95th percentile and would be missed based on their initial blood pressure (ie false negative). In 71.4% of youth with an initial blood pressure ≥95th percentile, the lower of two blood pressure readings was <95th percentile.

In youth with a blood pressure ≥95th percentile during an outpatient visit, two more follow-up visits are recommended to meet a diagnosis of hypertension and further work-up should be considered. About 32.2% of youth with a visit indicating hypertension stage I completed the recommended follow-up within 3 months **(Table 2)**. Completion of follow-up visits varied slightly but significantly and was somewhat higher in older and lower in minority youth.

For the majority of youth with an initial blood pressure ≥95th percentile during an outpatient visit, the required follow-up to confirm or rule out hypertension was not completed and their blood pressure status could not be determined (n=114,206, 67.8%). Among those with the required follow-up visits (n=54,354), hypertension was not sustained in 97.7% of youth with an initial blood pressure ≥95th percentile (**Figure 2**). Only 2.3% of youth continued to have blood pressure ≥95th percentile indicating hypertension stage I.

Hypertension stage II

In youth for which the initial high blood pressure ≥99th + 5mm Hg percentile was repeated during their visit (n=9,840), 35.0% of youth also had a mean blood pressure ≥99th + 5mm Hg percentile (**Figure 1**). Among youth with an initial blood pressure ≥99th + 5mm Hg percentile, the mean of two blood pressure was <95th percentile in 65.0% of youth who would be false positive results if the blood pressure would not have been repeated. In 81.0% of youth with an initial blood pressure ≥99th + 5mm Hg percentile, the lower of two blood pressure readings was <95th percentile.

About 31.7% indicating hypertension stage II, respectively, completed the recommended follow-up within 3 months **(Table 2)**. This was significantly higher in older than in younger patients (36.1% in 12-17 yr olds vs. 28.4% in 3-5 yr olds) and lower in most minority youth. For the majority of youth with an initial blood pressure ≥99th + 5mm Hg percentile during an outpatient visit, the required follow-up to confirm or rule out hypertension was not completed

and could not be determined (n=8,646, 68.3%). Among those with the required follow-up visits, hypertension was sustained in 11.3% of youth with an initial blood pressure ≥99th + 5mm Hg percentile, but not sustained in 88.7% (**Figure 2**). Hypertension was sustained at the hypertension stage II level in 7.3%, and at the hypertension stage I level in 4.0% of those with an initial blood pressure ≥99th + 5mm Hg percentile during an outpatient visit.

DISCUSSION

Blood pressure in the hypertensive range are very common in clinical care as first readings. Almost 1 out of four youth between 3-17 years of age had at least one blood pressure ≥95th percentile for sex, age, and height. Current clinical practice guidelines for evaluation of elevated blood pressure in children and adolescents recommend to repeat an elevated office blood pressure reading at the same visit, but there are few data available to support this recommendation. The present study showed that blood pressure was not repeated during the same visit as recommended in almost 80% of youth. Less than half of the pediatric patients (45.9%) would be correctly classified based on their initial blood pressure; the failure to repeat a high blood pressure at the time of the initial visit resulted in a large proportion of false positives (here 54.1%) from general blood pressure screening. Our results also indicate that if asymptomatic youth are screened and followed up as recommended within 3 months, hypertension was confirmed in only a small proportion of youth. About 2% of youth with an initial visit indicating hypertension stage I, and 11% of youth with an initial visit indicating hypertension stage II continued to have high blood pressure during their follow-up visits.

Several issues pose significant challenges for pediatricians to effectively screen high blood pressure in youth. For adults, simple and straight-forward blood pressure cut-off values guide clinical decision-making while the definition of high blood pressure in youth is much more complex. The definition of normal blood pressure values in children and adolescents varies by

sex, age and height. Values from blood pressure readings need to be converted into blood pressure percentiles available in standardized tables, which takes time. Because blood pressure in youth varies, it is recommended to repeat high blood pressure readings during the same visit and to schedule follow-up visits to confirm sustained hypertension in 3 independent medical visits for a diagnosis of hypertension and for further evaluation of underlying causes in youth. Our understanding of the implications of non-adherence to screening guidelines with regard to the potential misclassification of a normotensive patient as hypertensive when conducting studies using EMR data or missing patients with true hypertension is limited.

While screening for high blood pressure in asymptomatic youth is recommended as an important strategy for early diagnosis and treatment of hypertension to prevent cardiovascular disease.[13-19] the implications of general blood pressure screening for clinical care have to be considered. The results of our study show that almost 25% of youth had at least one high blood pressure recorded in their EMR if a general screening is performed at every visit. These visits are not limited to well-child visits but include acute care visits. In a recent large study of several health care systems, only 5% of youth had a high blood pressure during well-child visits.[6] Considering the high proportion of youth with a high blood pressure reading resulting from general screening at every visit, following standardized screening procedures and adherence to recommendations such as the repetition of initial high blood pressure readings is crucial to avoid unnecessary follow-up visits but also to prevent that true hypertension is overlooked and under-diagnosed in high-risk youth.[21, 22]

The failure to repeat a high blood pressure at the time of the initial visit is concerning because the large number of false positives (here 54.1%) from general blood pressure screening in asymptomatic youth would almost double the number of youth estimated to have a hypertensive blood pressure and would require additional follow-up visits. The calculation of the

mean blood pressure during the same visit may be a barrier towards blood pressure screening in youth. If the lower of two blood pressure readings would be used as visit result, an initial blood pressure ≥95th percentile was not confirmed in 71.4% of youth (81.0% of youth with an initial blood pressure ≥99th + 5mm Hg percentile). Appropriate training for providers and office staff on the importance of using standardized blood pressure screening protocols, especially the importance to repeat an initial high blood pressure during the same visit is necessary. If the proportion of false positives can be reduced, resources can be directed towards youth who benefit from follow-up by confirming or ruling out true hypertension. Providers may be inclined to dismiss a first high blood pressure, especially if a child was upset. It may be common practice to accept the last blood pressure as the valid blood pressure, and averaging blood pressures may not occur as recommended. Using the lower versus the mean of blood pressure readings during a visit may simplify the efforts for providers but studies are needed to compare the of both methods towards their effectiveness to detect youth with true hypertension.

To overcome some of the challenges associated with blood pressure screening in the clinical setting in which the present study was conducted, EMR tools were developed that translate absolute blood pressure values into blood pressure percentiles and provide easy access to blood pressure history during a visit. Results from the present study indicate that simple tools translating blood pressure into percentiles were not successful to achieve a high adherence to current recommendations to screen for high blood pressure in asymptomatic youth. The adherence to recommendations such as the repetition of high blood pressure readings during the same visit and the scheduling of follow-up visits was low. Studies are needed to test the efficiency of EMR-embedded decision support tools which populate alerts to the provider regarding high blood pressure and the recommended best practice for each patient based on their blood pressure and medical history.

Blood pressure in youth varies and a high blood pressure often reverses to normal without any intervention.[7] Therefore, the criteria for diagnosing hypertension in youth require sustained hypertension in 3 independent medical visits. If an initial high blood pressure is not recognized or dismissed, a follow-up visit may not be scheduled as recommended. In a school-based study, the proportion of youth with elevated blood pressure based on one visit was five times higher than based on three measurements taken within a few weeks.[32] In our study, initial hypertension was confirmed during follow-up visits in only 2.3% of pediatric patients with an initial high blood pressure indicating hypertension stage I and 11.3% of pediatric patients with an initial high blood pressure indicating hypertension stage II. The majority of youth did not meet the criteria for sustained hypertension. Future studies in a clinical environment with a high adherence to the current screening guidelines are necessary to estimate the rate of sustained hypertension across different population groups defined by sex, age, race, and other potential risk factors.

Findings from our study indicate that only about 1 out of 3 of patients have the recommended follow-up visits after a visit with an initial high blood pressure within 3 months. This finding is consistent with other studies, in which 80% and more pediatric patients with high blood pressure did not have a follow-up as recommended.[20-22] Automated tools and alerts systems may support this process as shown in other settings.[22] However, the results from the present study indicate that simple tools translating blood pressure into percentiles as used here, are not sufficient and need to be replaced by more sophisticated and automated computer-assisted support tools which populate alerts and provide best practice advice.

Several strength and limitations should be noted. The large and diverse population-based sample allows us to estimate the prevalence of high blood pressure and the potential misclassification in defined subpopulations in routine outpatient medical visits. Several

measurements were taken to ensure high quality and that blood pressure readings followed strict protocols according to published recommendations.[19, 31, 33] However, this may not always be the case in clinical practice. We cannot ensure that blood pressures were accurately measured during all routine care visits. The intensity of in-house training may have varied by medical center. Deviations of the preferred measurement method may have occurred. It is possible that additional blood pressure measurements were performed, but were not documented in the EMR system or captured through data abstraction. This would have led to an underestimation of adherence to current blood pressure screening guidelines. However, due to the current clinical work flows, constant training and quality checks, these deviations are unlikely to have affected the results. Another potential limitation is the type of device used in clinical settings. Automated digital blood pressure monitors are the preferred devices while standard blood pressure values were developed based on standard mercury sphygmomanometers. However, the use of automated devices is frequent in clinical settings.[34] Measurement error may explain the high number of youth with initial high blood pressure; it may also be difficult to get accurate blood pressure readings for children regardless of the type of device in real-life clinical situations when assessing blood pressure at every visit. While we cannot exclude errors from the use of automated digital blood pressure monitors, our results cannot be explained by a slight but systematic overestimation caused by these devices. However, the proportion of youth with high blood pressure observed here was high compared to other studies using automated digital devices.[6] Moreover, the proportion of false positives was particularly high when using the lower of two readings as standard. These facts suggest that our observation was not a device issue but a matter of practicality or training to achieve accurate blood pressure readings for children during routine clinic visits. Last, the adherence to recommendations to repeat blood pressures during the same visit and to schedule follow-up visits was low. This may limit the generalizability of the magnitude of misclassification and the proportion of youth with sustained high blood pressure. However, we carefully examined a variety of risk factors that may indicate selection

bias. For the repetition of high blood pressure readings during the same visit, we observed that patients were more likely to have a repeated blood pressure if they were male, older and obese. This observation suggests that the magnitude of misclassification may be higher in patients who are younger, female, and not obese. In contrast, scheduling appropriate follow-up visits after an initial visit with high blood pressure was remarkably independent of known risk factors for hypertension and suggests that high blood pressure is ignored in youth regardless of risk factors.

In conclusion, our findings suggest that a high initial blood pressure reading in youth is common while the proportion of youth with sustained hypertension is low. Repeating an initial hypertensive blood pressure during the same visit as recommended by current guidelines is important to rule out false positives and to avoid unnecessary follow-up visits due to the necessity to confirm if the hypertensive blood pressure persists. Staff training needs to emphasize the importance of repeating high blood pressure readings.

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Figure Legend

Figure 1.

Visit result classification of pediatric patients with blood pressure indicating hypertension stage I or II based in the initial blood pressure reading compared to the mean of two blood pressure readings.

Figure 2.

Hypertension status in pediatric patients with an initial visit indicating hypertension stage I or stage II after completing their follow-up visits.

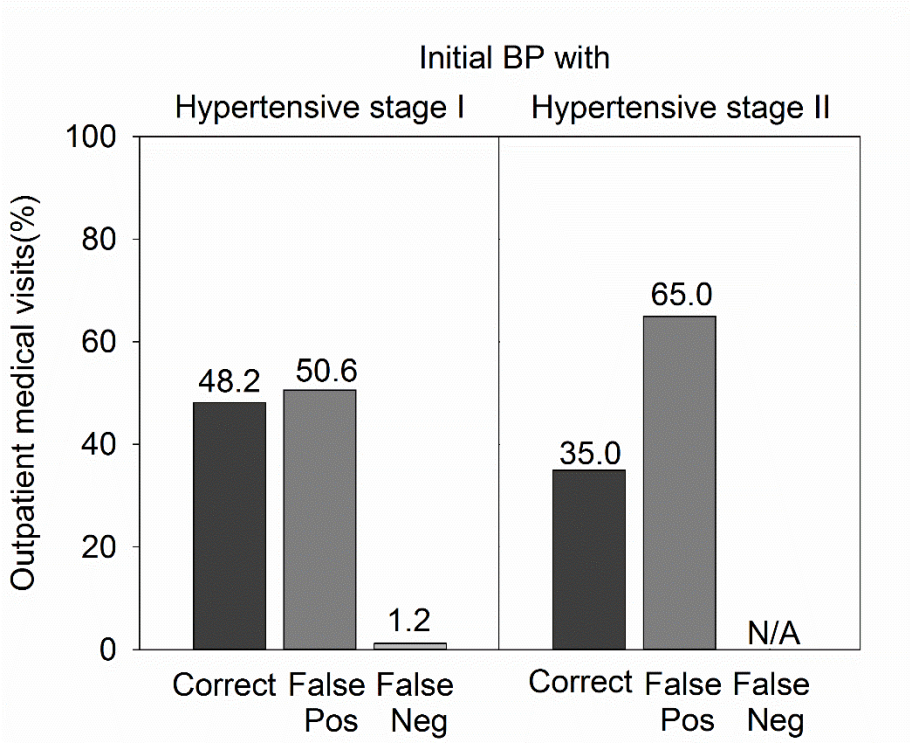

Figure 1.

Visit result classification of pediatric patients with blood pressure indicating hypertension stage I or II based in the initial blood pressure reading compared to the mean of two blood pressure readings.

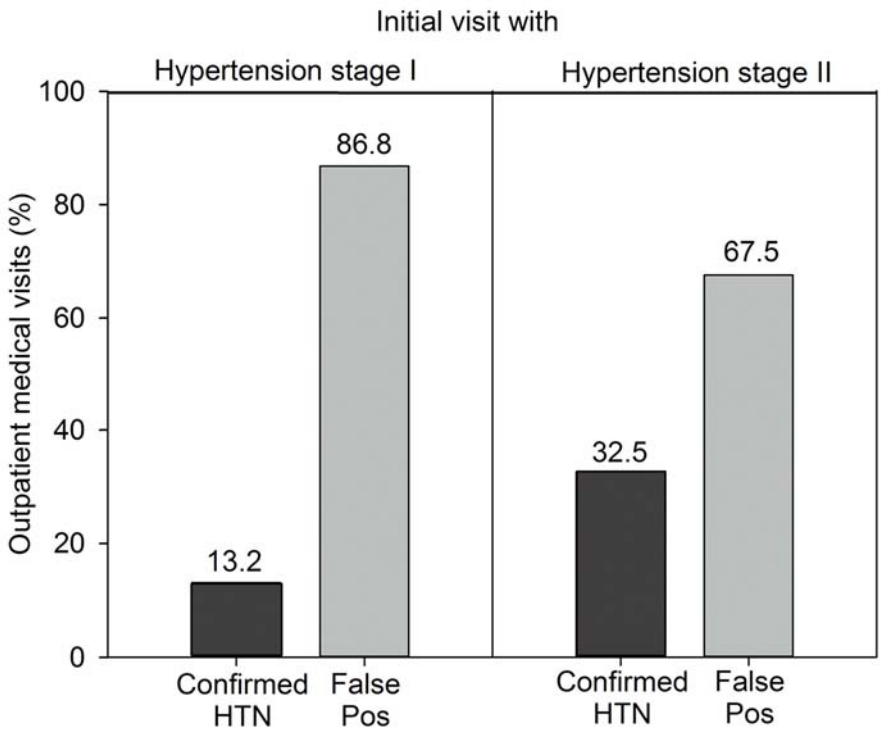

Figure 2.

Hypertension status in pediatric patients with an initial visit indicating hypertension stage I or stage II after completing their follow-up visits.

Tables

Table 1.

Cohort characteristics and repetition of a high blood pressure during outpatient medical visits for 186,732 youth in 2012-2015 with a first blood pressure (BP) ≥95th percentile (hypertension stage I) or ≥99th percentile plus 5 mm Hg (hypertension stage II)

	Total[1]	Repetition[2]		RR (95% CI)	
		Yes	No	Crude	Adjusted
First blood pressure ≥95th percentile and <99th percentile plus 5 mm Hg (n = 167,402)					
Sex					
Male	88,437 (52.8)	18,210 (20.6)	70,227 (79.4)	Ref	Ref
Female	78,965 (47.5)	12,355 (15.6)	66,610 (84.4)	0.76 (0.74-0.78)	0.76 (0.74-0.77)
Age (years)					
3-5	46,480 (27.8)	4,184 (9.0)	42,296 (91.0)	Ref	Ref
6-11	53,822 (32.2)	7,420 (13.8)	46,402 (86.2)	1.53 (1.48-1.59)	1.50 (1.45, 1.55)
12-17	67,100 (40.1)	18,961 (28.3)	48,139 (71.7)	3.14 (3.04-3.24)	3.07 (2.98, 3.17)
Race/Ethnicity					
Non-Hispanic/White	40,790 (24.4)	7,035 (17.2)	33,755 (82.8)	Ref	Ref
Hispanic	87,814 (52.5)	16,271 (18.5)	71,543 (81.5)	1.07 (1.05-1.10)	1.01 (0.99-1.04)
African American	13,626 (8.1)	2,354 (17.3)	11,272 (82.7)	1.00 (0.96-1.05)	0.98 (0.94-1.02)
Asian/Pacific Islander	15,568 (9.3)	3,162 (20.3)	12,406 (79.7)	1.18 (1.13-1.22)	1.21 (1.17-1.26)
Other/Unknown	9,604 (5.7)	1,743 (18.1)	7,861 (81.9)	1.05 (1.00-1.10)	1.04 (1.00-1.09)
BMI class					
Underweight/Normal	86,948 (51.9)	13,863 (15.9)	73,085 (84.1)	Ref	Ref
Overweight	31,057 (18.6)	5,992 (19.3)	25,065 (80.7)	1.21 (1.18-1.24)	1.07 (1.04-1.10)
Moderately obese	31,654 (18.9)	6,559 (20.7)	25,095 (79.3)	1.30 (1.27-1.33)	1.12 (1.10-1.15)
Severely obese	17,721 (10.6)	4,138 (23.4)	13,583 (76.6)	1.46 (1.42-1.51)	1.17 (1.14-1.21)
Unknown	22 (0)	13 (59.1)	9 (40.9)	3.71 (2.62-5.25)	2.37 (1.74-3.24
First blood pressure ≥99th percentile plus 5 mm Hg (n = 19,330)					
Sex					
Male	10,430 (54.0)	5,560 (53.3)	4,870 (46.7)	Ref	Ref

Female	8,900 (46.0)	4,280 (48.1)	4,620 (51.9)	0.90 (0.88-0.93)	0.97 (0.95-0.98)
		Age (years)			
3-5	6,090 (31.5)	1,332 (21.9)	4,758 (78.1)	Ref	Ref
6-11	5,318 (27.5)	2,338 (44.0)	2,980 (56.0)	2.01 (1.90-2.13)	1.26 (1.12-1.30)
12-17	7,922 (41)	6,170 (77.9)	1,752 (22.1)	3.56 (3.39-3.74)	1.67 (1.67-1.71)
Race/Ethnicity					
Non-Hispanic/White	4,760 (24.6)	2,318 (48.7)	2,442 (51.3)	Ref	Ref
Hispanic	10,065 (52.1)	5,240 (52.1)	4,825 (47.9)	1.07 (1.03-1.11)	0.99 (0.97-1.01)
African American	1,548 (8)	796 (51.4)	752 (48.6)	1.06 (1.10-1.12)	0.99 (0.96-1.02)
Asian/Pacific Islander	1,768 (9.1)	862 (48.8)	906 (51.2)	1.00 (0.95-1.06)	1.03 (1.00-1.06)
Other/Unknown	1,189 (6.2)	624 (52.5)	565 (47.5)	1.08 (1.01-1.15)	1.01 (0.98-1.05)
BMI class					
Underweight/Normal	8,836 (45.7)	3,622 (41.0)	5,214 (59.0)	Ref	Ref
Overweight	3,391 (17.5)	1,871 (55.2)	1,520 (44.8)	1.35 (1.29-1.40)	1.03 (1.01-1.06)
Moderately obese	4,036 (20.9)	2,326 (57.6)	1,710 (42.4)	1.41 (1.36-1.46)	1.04 (1.02-1.06)
Severely obese	3,056 (15.8)	2,012 (65.8)	1,044 (34.2)	1.61 (1.55-1.66)	1.06 (1.03-1.08)
Unknown	11 (0.1)	9 (81.8)	2 (18.2)	2.00 (1.51-2.64)	1.20 (0.67-2.14)

Relative risk (RR) was calculated using a log binomial model with and without adjustment for all variables listed in the table.
Data are provided for total cohort[1] as column % and by blood pressure repetition[2] as row %

Table 2

Completion of the recommended follow up after an initial outpatient visit with high blood pressure in youth with a first blood pressure (BP) ≥95th percentile (hypertension stage I) or ≥99th percentile plus 5 mm Hg (hypertension stage II) shown as relative risk.

		Time to complete follow up (n, %)		RR (95% CI) for completion ≤3 month	
	Total[1]	**≤3 month**	**>6 months***	**Crude**	**Adjusted**
First blood pressure ≥95th percentile and <99th percentile plus 5 mm Hg					
N	155,901	50,155 (32.2)	55,490 (67.8)		
Blood pressure repeated at initial visit					
No	135,980 (87.2)	43,903 (32.3)	92,077 (67.7)	Ref	Ref
Yes	19,921 (12.8)	6,252 (31.4)	13,669 (68.6)	0.97 (0.95, 0.99)	0.92 (0.90, 0.94)
Gender					
Male	81,649 (52.4)	26,651 (32.6)	54,998 (67.4)	Ref	Ref
Female	74,252 (47.6)	23,504 (31.7)	50,748 (68.3)	0.97 (0.96, 0.98)	0.97 (0.95, 0.98)
Age at first BP (years)					
3-5	44,654 (28.6)	12,780 (28.6)	31,874 (71.4)	Ref	Ref
6-11	50,668 (32.5)	15,997 (31.6)	34,671 (68.4)	1.10 (1.08, 1.12)	1.11 (1.08, 1.13)
12-17	60,579 (38.9)	21,378 (35.3)	39,201 (64.7)	1.23 (1.21, 1.26)	1.24 (1.22, 1.27)
Race/Ethnicity					
Non-Hispanic/White	38,082 (24.4)	12,888 (33.8)	25,194 (66.2)	Ref	Ref
Hispanic	81,807 (52.5)	26,779 (32.7)	55,028 (67.3)	0.97 (0.95,0.98)	0.96 (0.94, 0.98)
African American	12,744 (8.2)	4,013 (31.5)	8,731 (68.5)	0.93 (0.90,0.96)	0.93 (0.90,0.95)
Asian/Pacific Islander	14,246 (9.1)	3,934 (27.6)	10,312 (72.4)	0.82 (0.79,0.84)	0.82 (0.80, 0.85)
Other/Unknown	9,022 (5.8)	2,541 (28.2)	6,481 (71.8)	0.83 (0.80,0.86)	0.83 (0.80, 0.86)
BMI closest to first BP					
Underweight/Normal	47,084 (51.6)	11,861 (25.2)	28,924 (61.4)	Ref	Ref
Overweight	15,733 (18.5)	3,862 (24.5)	9,879 (62.8)	0.97 (0.94, 1.01)	0.98 (0.95, 1.02)
Moderately obese	16,533 (19.1)	4,132 (25.0)	10,247 (62.0)	0.99 (0.96, 1.02)	1.00 (0.97, 1.03)
Severely obese	10,108 (10.8)	2,492 (24.7)	6,393 (63.3)	0.98 (0.94, 1.02)	0.99 (0.95, 1.03)

Unknown	58 (0.0)	10 (17.2)	47 (81.1)	0.68 (0.39, 1.20)	0.73 (0.42, 1.29)
First blood pressure ≥99th percentile plus 5 mm Hg					
N	12,659	4,013 (31.7)	8,646 (68.3)		
Blood pressure repeated at initial visit					
No	9,384 (74.1)	2,884 (30.7)	6,500 (69.3)	Ref	Ref
Yes	3,275 (25.9)	1,129 (34.5)	2,146 (65.5)	1.12 (1.06, 1.19)	1.03 (0.96, 1.09)
Gender					
Male	6,653 (52.6)	2,112 (31.7)	4,541 (68.3)	Ref	Ref
Female	6,006 (47.4)	1,901 (31.7)	4,105 (68.3)	1.00 (0.95, 1.05)	1.00 (0.95, 1.05)
Age at first BP (years)					
3-5	5,090 (40.2)	1,447 (28.4)	3,643 (71.6)	Ref	Ref
6-11	3,714 (29.3)	1,176 (31.7)	2,538 (68.3)	1.11 (1.04, 1.19)	1.12 (1.05, 1.20)
12-17	3,855 (30.5)	1,390 (36.1)	2,465 (63.9)	1.27 (1.19, 1.35)	1.27 (1.18, 1.36)
Race/Ethnicity					
Non-Hispanic/White	3,140 (24.8)	996 (31.7)	2,144 (68.3)	Ref	Ref
Hispanic	6,560 (51.8)	2,166 (33.0)	4,394 (67.0)	1.04 (0.98, 1.11)	1.03 (0.97, 1.10)
African American	1,019 (8.1)	313 (30.7)	706 (69.3)	0.97 (0.87, 1.08)	0.95 (0.86, 1.06)
Asian/Pacific Islander	1,158 (9.1)	318 (27.5)	840 (72.5)	0.87 (0.78, 0.96)	0.88 (0.79, 0.97)
Other/Unknown	782 (6.2)	220 (28.1)	562 (71.9)	0.89 (0.78, 1.00)	0.88 (0.77, 0.99)
BMI closest to first BP					
Underweight/Normal	6,139 (48.5)	1,894 (30.9)	4,245 (69.1)	Ref	Ref
Overweight	2,101 (16.6)	684 (32.6)	1,417 (67.4)	1.06 (0.98, 1.13)	0.99 (0.92, 1.07)
Moderately obese	2,474 (19.6)	801 (32.4)	1,673 (67.6)	1.05 (0.98, 1.12)	0.97 (0.90, 1.04)
Severely obese	1,936 (15.3)	632 (32.6)	1,304 (67.4)	1.06 (0.98, 1.14)	0.94 (0.87, 1.02)
Unknown	9 (0.0)	2 (0.0)	7 (0.0)	0.72 (0.21, 2.45)	0.67 (0.20, 2.26)

*Includes patients with no follow-up at the end of the study period.

Data are provided for total cohort[1] as column % and by blood pressure repetition[2] as row %