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# Effects of the 2017 clinical practice guidelines on hypertension in children and adolescents: A commentary

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Editorial

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The Fourth Report on the Diagnosis, Evaluation, and Treatment of High Blood Pressure in Children and Adolescents (Fourth Report) was published in 2004 [1]. Subsequent research on blood pressure (BP) in children led to many reports on the increasing prevalence of abnormal BP in children, and on factors associated with abnormal BP that contributed to heightened risk for cardiovascular disease in early adulthood. Based on an expanded body of knowledge, the American Academy of Pediatrics sponsored an update of the pediatric BP guidelines. The Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents (CPG) was published in 2017 [2], and provides comprehensive clinical guidance for detection, diagnosis, and management of abnormal BP in pediatric patients. The overall clinical approach in evaluation and management of hypertension in children and adolescents is similar to the previous Fourth Report. However, two key changes in the new CPG are likely to confer a change in detection and prevalence of abnormal BP and hypertension in youth. There is a consistent positive association of overweigh and obesity status with higher BP in childhood [3,4]. Removal of BP data on children with body mass index (BMI) > 85th percentile in the child normative BP database resulted in a somewhat lower BP level at each sex, age, and height adjusted BP percentile [5]. These BP tables, based on normal weight children were used in the 2017 CPG. In the new tables, the BP levels at the 90$^{th}$ and 95th percentile, used to define abnormal BP and hypertension, are 2–3 mmHg lower than the systolic and diastolic BP levels in the Fourth Report.

The definition of hypertension in children <13 years of age remains unchanged as systolic and/or diastolic BP ≥ 95th percentile. BP levels in children previously termed "prehypertension" are now termed "elevated BP" and for children <13 years of age. Elevated BP is defined as BP ≥ 90$^{th}$ percentile and <95th percentile. Normal BP for children <13 is <90$^{th}$ on the sex, age, height adjusted BP tables. More significant changes were made in the definition of hypertension for adolescents ≥13 years of age. For both males and females from age 13 and above a numerical value is used to define BP status. Normal BP is < 120/80 mmHg. Elevated BP is 120–129/<80 mmHg. Hypertension stage 1 is 130–139/80–89 mmHg. Hypertension stage 2 is >140/90 mmHg. These numerical values for hypertension in adolescents are close to the 95th percentile, on the revised BP tables, for most adolescents beginning at age 13 years, with the exception of young very short adolescents. These definitions are also identical to the new definitions of elevated BP and hypertension in the recent update of the adult hypertension guidelines developed by the American Heart Association and the American College of Cardiology [6]. The new CPG definitions of elevated BP and hypertension in adolescents is expected to simplify recognition of abnormal BP in adolescents and also expected to harmonize management in the progression from adolescence to young adulthood.

Since publication of the CPG in 2017, several reports on the impact of the new guideline have been published. These recent reports are based on analysis of existing data previously obtained on child populations or longitudinal cohorts with initial measurement of BP obtained in childhood. Sharma et al. [7] examined data on 15,647 generally healthy children age 5–18 years from the National Health and Nutrition Examination Surveys (NHANES) in the period 1999 to 2014. Participants had BP classification based on the Fourth Report. Using the CPG to redefine BP status in these children resulted in an increase in prevalence of hypertension from 11.8% (95% CI, 11.1%–13.0%), based on the Fourth Report, to 14.2% (95% CI, 13.4–15.0) based on the CPG. Within the entire cohort, 905 children (5.8%) had newly diagnosed hypertension or an increase in BP status based on the new CPG. These children were matched by sex, age, and height with controls having normal BP. Children having BP status reclassified upward were more likely to be obese, have adverse lipid profiles and increased hemoglobin A1c levels. These results indicate that the upward classification of BP status, based on the CPG, in this cohort of otherwise healthy children, represent a high-risk group of children whose cardiovascular risk may have been underestimated by the Fourth Report.

Another recent report examined the impact of the CPG in a cohort of high-risk youth. Khoury et al. [8] examined application of the CPG on hypertension and association with target organ damage (TOD) measures in a cohort of 364 adolescents age 10–18 years with obesity and type 2 diabetes. TOD measurements included carotid artery intima-media thickness, pulse wave velocity, left ventricular mass, and diastolic function. The prevalence of hypertension increased from 8% based on the

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Fourth Report to 13% based on the CPG. The two guidelines both showed similar associations of BP with TOD. However, the new CPG demonstrated improved sensitivity for TOD detection. As an example, the portion of participants, classified as hypertensive, with abnormal left ventricular mass increased from 20%, based on the Fourth Report, to 32% based on the CPG. These results indicate that the new CPG may improve detection of cardiac injury markers in high-risk children.

In another study, Bell et al. [9] reanalyzed data from the Houston Pediatric and Hypertension school screening program on 22,224 children age 10–17 years. BP status in this cohort of school children had been classified according to criteria in the Fourth Report. The authors reported that with application of the new CPG criteria, the prevalence of elevated BP, previously termed prehypertension, increased from 14.8% to 16.3%. The prevalence of confirmed hypertension, based on repeated measurement, remained at 2%–4%. It was also noted that, based on the CPG, shorter children <13 years and taller older children (>13 years) were more likely to be up-classified in BP status.

The new CPG was compared to the Fourth Report on an even larger cohort by Dong et al. [10] The BP status and related risk factors were compared in 50,336 Chinese youth age 6–17 years. The prevalence of high BP (both elevated BP and hypertension) was higher based on the CPG at 16.7% of children <13 years and 7.9% of adolescents compared to 10.6% in children and 6.3% of adolescents based on the Fourth Report. The prevalence estimates for high BP differed the greatest for boys, children aged 11 years, those with high BMI, and those with tall stature. In support of the CPG validity were strong associations between high BP with BMI and other medical and behavioral factors. In a similar study, Al Kibria et al. [11] compared the prevalence of hypertension according to the Fourth Report and the CPG based on BP data of children age 8–17 years in two separate NHANES periods. Their analysis included 3633 children in NHANES 2005–2008 and 3471 children in NHANES 2013–2016. In the 2005–2008 NHANES period, the prevalence of hypertension was 3.1% based on the Fourth Report classification (95% CI, 2.3–4.3%). When BP status in this period was recalculated according to the CPG, the prevalence of hypertension was 5.7% (95% CI, 4.6–7.1%). Similarly, in the 2013–2016 NHANES period the prevalence of hypertension based on the Fourth Report was 1.9% (95% CI, 1.4–2.6%). When recalculated according to the CPG, the prevalence of hypertension was 3.5% (95% CI, 2.7–4.5%). Thus, the change in reference tables and definition of hypertension for children ≥13 years results in the expected increase in prevalence of childhood hypertension.

In another recent study, Kharbanda et al. [12] examined clinical BP data of children and adolescents who were well-child patients, age 10–17 years, in a large primary care health system. Data were available in electronic clinical records on individual patients over several years. The investigators designed a prospective study and sought to determine the rates of incident hypertension following persistent elevated BP based on the new CPG compared to the Fourth Report. In this large cohort, 2025 youth (mean age 14.6 years) had elevated BP on repeated visits. During a two-year follow-up period, 5.9% progressed to hypertension based on CPG criteria compared to 1.1% based on Fourth Report criteria. Those who progressed to hypertension tended to be older and obese. Overall, the progression from elevated BP to hypertension was over 5-fold greater based on the CPG compared to the Fourth Report. These results suggest that the CPG may have greater capacity to identify youth with heightened risk for progression in BP status.

The Bogalusa Heart Study is a longitudinal cohort study that enrolled 3940 children. Child participants were then followed with repeated measurements into mid-adulthood. Age at enrollment ranged from 3 to 18 years. Du et al. [13] conducted a study to evaluate cardiovascular consequences of childhood hypertension based on the CPG definition of hypertension compared to the Fourth Report definition of hypertension in childhood. The major goal of this study was to compare performance of these two guidelines in predicting adult hypertension, metabolic syndrome, and left ventricular hypertrophy (LVH). In childhood, hypertension was identified in 7% of the cohort by Fourth Report criteria compared to 11% of the cohort according to the CPG. Both guidelines had similar significant associations of childhood BP with adult hypertension, metabolic syndrome, and LVH. However, the portion of children identified as hypertensive in childhood who developed LVH in adulthood increased from 12% identified by the Fourth Report to 19% of those identified by the CPG. Thus, the new CPG guideline identified a group of children with heightened risk for adverse cardiovascular outcomes, a risk that was under-estimated by the Fourth Report guideline.

The above reports, based on existing data from large cohorts, compare prevalence of abnormal BP, associated risk factors, and outcomes based on the new CPG compared to the Fourth Report. The elimination of BP data on overweight and obese children from the normative BP data tables lowered the BP levels at the 90$^{th}$ and 95 percentile BP level; and it was expected to increase the childhood prevalence of elevated BP and hypertension somewhat. To date, the new CPG appears to provide greater sensitivity in detection of youth with other risk factors associated with abnormal BP. The new CPG may also enable early recognition of youth at greater risk for premature cardiovascular disease in early adulthood. Additional study is needed on the effect of the change in definition of abnormal BP for children ≥13 years of age, wherein a single number defines hypertension in boys and girls and is equivalent to the definition in older adults.

## Conflict of interest

None.

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