ISH Paper

# Practical approach to evaluate and manage hypertension in youth: an International Society of Hypertension position paper

Joseph T. Flynn[a,*], Ruan Kruger[b,c,*], Tammy M. Brady[d], Rahul Chanchlani[e], Janis Dionne[f], Adriana Iturzaeta[g], Tazeen H. Jafar[h], Erika S.W. Jones[i], Hidehiro Kaneko[j], Anastasios Kollias[k], Nicholas Larkins[l], Jonathan Mynard[m,n,o], Peong G. Park[p], Manish D. Sinha[q], Stella Stabouli[r], Andrew Tran[s], Marina Vaccari[t], and George Stergiou[u]

Hypertension in children and adolescents is an increasingly prevalent global health concern and a strong predictor of adult cardiovascular and kidney disease. Variability in existing guidelines and limited applicability in low-resource settings hinder effective identification and management. This International Society of Hypertension (ISH) position paper provides practical, harmonized guidance for clinicians globally. To develop evidence-based, clinically relevant recommendations for the evaluation, diagnosis, and management of hypertension in youth, informed by multidisciplinary expertise from 12 countries. An expert panel undertook an iterative, consensus-driven synthesis of current evidence covering epidemiology, risk factors, blood pressure measurement, diagnostic evaluation, target organ injury, lifestyle therapy, pharmacological treatment, and long-term monitoring. Youth hypertension is driven by obesity, adverse childhood experiences, unhealthy lifestyle behaviors, and socioecological factors, with a disproportionately higher burden in low and middle-income countries. Accurate diagnosis requires standardized measurement using validated devices, proper cuff sizing, and out-of-office monitoring, particularly ambulatory blood pressure monitoring. Targeted investigations help distinguish primary from secondary hypertension and identify early organ injury. Lifestyle modification forms the foundation of treatment, while pharmacotherapy is indicated for persistent stage 2 hypertension, comorbid conditions, or evidence of organ damage. Structured transition to adult care is essential to improve long-term adherence and outcomes. Timely recognition and individualized management of youth hypertension are critical for reducing lifelong cardiovascular risk. This ISH position paper offers pragmatic, globally adaptable recommendations to enhance early detection, treatment, and continuity of care for children and adolescents with elevated blood pressure.

**Keywords:** adolescent, ambulatory blood pressure, blood pressure, child, echocardiography, hypertension

**Abbreviations:** AAP, American Academy of Pediatrics; ABPM, Ambulatory Blood Pressure Monitoring; ACE, Adverse Childhood Experiences; BP, blood pressure; CV, Cardiovascular; CVD, Cardiovascular Disease; DASH, Dietary Approaches to Stop Hypertension; ESH, European Society of Hypertension; HBPM, Home Blood Pressure Monitoring; HIC, High-Income Countries; ISH, International Society of Hypertension; LMIC, Low and Middle-Income Countries; LVH, Left Ventricular Hypertrophy; LVM, Left Ventricular Mass; TOI, Target Organ Injury; US, United States

## INTRODUCTION

While it is clear to clinicians and researchers alike that hypertension (HTN) is not uncommon in children and adolescents, how to best identify and care for youth with abnormal blood pressure (BP) has

Journal of Hypertension 2026, 44:000–000

[a]University of Washington, Seattle, Washington, USA, [b]Hypertension in Africa Research Team, [c]SAMRC Extramural Research Unit for Hypertension and Cardiovascular Disease, North-West University, Potchefstroom, South Africa, [d]Johns Hopkins University, Baltimore, Maryland, USA, [e]Division of Pediatric Nephrology, Department of Pediatrics, McMaster University, Hamilton, Ontario, [f]University of British Columbia, Vancouver, British Columbia, Canada, [g]Hospital General de Niños Dr Pedro de Elizalde, Buenos Aires, Argentina, [h]Duke-NUS Medical School, Singapore, Singapore, [i]Department of Nephrology and Hypertension, Groote Schuur Hospital, and Kidney and Hypertension Research Unit, University of Cape Town, Cape Town, South Africa, [j]Department of Cardiovascular Medicine, The University Tokyo, Tokyo, Japan, [k]Hypertension Center STRIDE-7, National and Kapodistrian University of Athens, School of Medicine, Third Department of Medicine, Sotiria Hospital, Athens, Greece, [l]Edith Cowan University, Perth, Western Australia, [m]Heart Research, Murdoch Children's Research Institute, [n]Department of Paediatrics, The University of Melbourne, [o]Department of Biomedical Engineering, The University of Melbourne, Parkville, Victoria, Australia, [p]Department of Pediatrics, Yonsei University College of Medicine, Seoul, Republic of Korea, [q]King's College London, British Heart Foundation Centre, London, UK, [r]1st Department of Paediatrics, Aristotle University Thessaloniki, Hippokratio Hospital, Thessaloniki, Greece, [s]Nationwide Children's Hospital, The Ohio State University, Columbus, Ohio, USA, [t]Hospital de Niños Ricardo Gutièrrez, Buenos Aires, Argentina and [u]Hypertension Center STRIDE-7, National and Kapodistrian University of Athens, School of Medicine, Third Department of Medicine, Sotiria Hospital, Athens, Greece

Correspondence to Ruan Kruger, PhD, North-West University, Potchefstroom 2531, North West South Africa. E-mail: ruan.kruger@nwu.ac.za

*Joseph T. Flynn and Ruan Kruger are co-first authors and share correspondence.

**Received** 15 December 2025 **accepted** 16 December 2025



DOI:10.1097/HJH.0000000000004238

been less clear. The various guidelines issued on this topic over the past several decades contain some common elements, but also many differences, and often are not applicable to settings outside of highly developed countries. Given this background, we set out to develop a practical guide for clinicians who encounter youth with HTN. This document is not intended to be a comprehensive clinical practice guideline, or to supplant those developed by consensus bodies. Rather we hope that the recommendations set out here will serve as a source of practical guidance and may also spur greater interest in the field.

## OBJECTIVE AND WRITING PROCESS

This International Society of Hypertension (ISH) position paper presents state-of-the-art recommendations developed by an international panel of pediatric HTN clinicians and researchers from 12 countries. Our intention is to provide recommendations for evaluation and management of youth with HTN that will be useful to pediatricians, internists, family physicians and other providers who may encounter such patients in their practice. The outline of the paper was developed through an iterative process by the two lead authors and then approved by the ISH Council. Author groups were formed for each section based upon individual expertise and interest. An initial draft was developed and assembled and was then circulated among the entire author group for review and revision aiming at reaching consensus.

## EPIDEMIOLOGY OF HIGH BLOOD PRESSURE IN CHILDREN AND ADOLESCENTS

### Definitions of hypertension; prevalence

Instead of an outcomes-based definition as in adults, the definition of HTN in children and adolescents is arbitrary and imperfect, as it is based on the normative distribution of BP in healthy children. As with any physiologic variable, BP is related to growth and development through childhood and adolescence until values analogous to those observed in young adults are reached. This means, as for other variables such as heart rate, cardiac output, or body mass index (BMI), no single threshold can define HTN throughout childhood [1].

HTN in pediatric populations is defined on thresholds of BP percentiles when the average SBP and/or DBP is equal to or above the 95th percentile on three or more occasions (usually in different visits), adjusted for age, sex, and height up to a certain age, according to different population-based criteria[2]. Due to regional variability in normal pubertal maturation, absolute cutoff values similar to those used in adults are adopted for adolescents (Table 1); these tend to be the same as cut-offs used in corresponding national adult guidelines [4–8]. Children with average SBP and/or DBP at least 90th percentile, but less than 95th percentile are classified as having high-normal BP. In addition, HTN is further classified as stage 1 HTN and stage 2 HTN (Table 1). This mirrors to some extent the categorization scheme used in adult guidelines [8]; although unlike in adults, this again is somewhat arbitrary and imperfect.

The prevalence of pediatric HTN worldwide is difficult to establish because of the regional differences in the definition, the distribution of reference BP data and the methods of BP measurement. According to a recent meta-analysis by Ruan *et al*[9]., sustained hypertension has been increasing annually, rising by just over 7% between 2006 and 2021. The study reported a prevalence of about 4% for sustained hypertension and roughly 12% for occasional [9]. Children with overweight or obesity showed a substantially higher burden, with sustained hypertension rates far exceeding those of their normal-weight peers [9,10].

### Risk factors for hypertension in childhood

The increasing prevalence of youth HTN is driven by complex interplay of factors, including the global childhood obesity epidemic, adverse childhood experiences (ACEs), and various lifestyle choices and behaviors, including sedentary lifestyle, screen time, sleep habits, dietary factors, among others. Understanding these interconnected drivers is crucial for developing effective prevention and intervention strategies in the general pediatric population. Obesity is arguably the most significant modifiable risk factor for HTN in youth [11]. Excess adiposity, particularly visceral obesity, leads to a cascade of physiological changes, including insulin resistance, increased sympathetic nervous system activity, activation of the renin-angiotensin-aldosterone system, and endothelial dysfunction, all of which contribute to increased BP. Beyond (and often in addition to) physiological mechanisms, the psychosocial environment plays a critical role. ACEs, such as physical or emotional abuse, neglect, household dysfunction (e.g., parental substance abuse, mental illness, divorce), exert a profound and lasting impact on health, including cardiovascular outcomes. A large-scale longitudinal study demonstrated that individuals who were exposed to multiple ACEs (including abuse, neglect, and household dysfunction) displayed a greater increase of BP levels in young adulthood compared to their counterparts without ACEs [12]. The chronic allostatic load imposed by ACEs can fundamentally alter cardiovascular regulatory mechanisms, making these children and adolescents more vulnerable to BP elevations.

Lifestyle factors, often intertwined with both obesity and ACEs, further contribute to pediatric HTN. Dietary and lifestyle factors are known to be associated with HTN among children and adolescents [13]. Diets high in processed foods, sugar-sweetened beverages, and sodium are thought to be linked to elevated BP [14,15]. A systematic meta-analysis demonstrated a positive association between higher screen time and higher risk of HTN in children and adolescents [16]. Poor sleep quality or insufficient sleep duration could disrupt autonomic nervous system function and hormone regulation, leading to higher BP [17–19]. These unhealthy lifestyles often contribute to obesity but can also independently impact vascular health.

Pediatric HTN is a multifactorial condition driven by the converging forces of obesity, ACEs, and suboptimal lifestyle choices. Addressing this growing public health concern requires a holistic approach that goes beyond weight management. Interventions must encompass comprehensive strategies to prevent and manage childhood obesity,

TABLE 1. Classifications of blood pressure in children and adolescents in international guidelines

| Issuing body | Year | Definitions: Normal BP | Definitions: Prehypertension/ high-normal/ elevated BP[b] | Definitions: Criteria of hypertension[a] | Comments |
|---|---|---|---|---|---|
| European Society of Hypertension (ESH) [1] | 2016 | < 90th percentile up to age 16y | ≥ 90th to < 95th percentile up to age 16y | ≥95th percentile for age-sex-height up to age 16y<br>Stage1: ≥ 95th to 99th pc + 5 mmHg<br>Stage2: > 99th pc + 5 mmHg | Static cut point based on adult thresholds in use at the time; percentiles based on normative BP data from 2004 Fourth Report |
| | | < 130/85 mmHg starting at 16y | 130 − 139/85 − 89 mmHg starting at 16y | ≥140/90 mmHg starting at 16y<br>Stage1: 140 − 159/90 − 99 mmHg<br>Stage2: 160 − 179/100 − 109 mmHg | |
| American Academy of Pediatrics (AAP) [2] | 2017 | < 90th percentile up to 13y | ≥ 90th to < 95th percentile or 120/80 mmHg to < 95th percentile (whichever is lower) up to 13y | ≥95th percentile for age-sex-height up to 13y or ≥130/80 mmHg up to 13y, (whichever is lower)<br>Stage 1: ≥ 95th percentile to < 95th percentile + 12 mmHg, or 130/80–139/89 mmHg (whichever is lower)<br>Stage2: ≥ 95th percentile + 12 mmHg, or ≥ 140/90 mmHg (whichever is lower) | Adopts static cut points from ACC/AHA guideline starting at 13y of age, percentiles based on revised; lower normative BP data<br>New age-sex-height nomograms only in normal weight |
| | | < 120/80 mmHg starting >13y | 120–129/ < 80 mmHg starting >13y | ≥130/80 mmHg starting >13y<br>Stage 1: 130/80–139/89 mmHg<br>Stage 2: ≥ 140/90 mmHg | |
| Chinese [3] | 2018 | < 90th percentile | ≥ 90th percentile to < 95th percentile; or 120/80 mmHg to < 95th percentile | ≥95th percentile for age and sex<br>Stage 1: ≥ 95th to < 99th percentile + 5 mmHg<br>Stage 2: ≥ 99th percentile + 5 mmHg | Percentiles based on Chinese-specific normative BP data |
| Japanese Society of Hypertension [4] | 2019 | n/a | n/a | ≥age-based static cut point ranging from 120/70 mmHg in preschool students to 140/85 mmHg in high-school students | Screening BP values 10–15 mmHg higher than those in percentile based reference charts |
| Hypertension Canada Guideline Committee [5] | 2020 | n/a | n/a | ≥95th percentile for age-sex-height; or ≥120/80 mmHg for age 6–11y, or ≥130/85 mmHg for ages ≥12y<br>Stage 1: ≥ 95th percentile to 95th percentile + 12 mmHg<br>Stage 2: > 95th percentile + 12 mmHg | Static cut points derived from one analysis of Bogalusa Heart Study.<br>Simplified fixed cut-off under and above 12 years<br>New age-sex-height nomograms only in normal weight |
| Argentine Consensus on Arterial Hypertension [6] | 2025 | < 90th percentile up to age 16y | ≥ 90th to < 95th percentile up to age 16y | ≥95th percentile for age-sex-height up to age 16 y<br>Stage 1: ≥ 95th percentile to < 95th percentile + 12 mmHg<br>Stage2: ≥ 95th percentile + 12 mmHg | Adaptation of New AAP BP tables for age-sex-height nomograms only in normal weight, for the Argentine pediatric population in the National School Health Program (including height values in cm) |
| | | < 130/80 mmHg starting at 16y | 130–139/80–89 mmHg starting at 16y | ≥140/90 mmHg for age 16y or older<br>Stage1: 140–159/90–99 mmHg<br>Stage2: ≥160/100 mmHg | |
| ESC 2022 Consensus panel [7] | 2022 | n/a | n/a | ≥95th percentile for age-sex-height up to age 16y; ≥130/85 mmHg for age 16 or older | New AAP BP tables of age-sex-height nomograms only in normal weight up to age 16y |

ACC, American College Cardiology; AHA, American Heart Association; BP, blood pressure; ESC, European Society of Cardiology.
[a]All require the child's BP to be at or above this level on multiple occasions (usually 3) before making the diagnosis of hypertension. n/a: not available.
[b]In the Fourth Report guideline, the classification of "prehypertension" is termed as "high-normal" in the ESH, United Kingdom, Canada and China guidelines, and "elevated" in the AAP guideline.

provide trauma-informed care to mitigate the effects of ACEs, and promote healthy lifestyle habits including regular physical activity, balanced nutrition, and adequate sleep. A deeper understanding of these complex interactions is essential for developing effective and equitable interventions to protect cardiovascular health, including HTN in future generations.

## Hypertension prevalence and risk factors in children and adolescents in high vs. low-and-middle-income countries

Data from systematic reviews and meta-analyses indicate that the prevalence of HTN is nearly double the global prevalence in sub-Saharan African and South Asian (6.9 vs. 4.0%) [10]. The higher BP observed among children in low and middle-income countries (LMICs) compared to those in high-income countries (HICs) is likely driven by factors such as rapid urbanization, increased sedentary behavior, limited availability of nutritious foods, higher sodium content in diet, and a greater rise in overweight and obesity rates in LMICs relative to HICs [20,21]. Additionally, evidence indicates that certain ethnic groups, particularly South Asians and Africans, may be at an increased risk for cardiovascular disease (CVD). For instance, children in Pakistan aged 5–15 years were shown to have higher SBP compared to their white counterparts in the United States, even after adjusting for BMI [22]. Prospective long-term birth cohort studies suggest that the increased susceptibility to HTN and vascular disease is influenced by socioecological, life course, and epigenetic factors, especially when compounded by peri-conceptional deprivation and rapid catch-up growth during early childhood [23,24]. Research is needed on innovative, comprehensive public health strategies for HTN care that not only manage HTN in children and adolescents but also address its social and commercial determinants, especially in LMICs.

## LINKS BETWEEN CHILDHOOD BLOOD PRESSURE AND ADULT CARDIOVASCULAR DISEASE

Childhood HTN tracks into adulthood, and children with HTN are also at a higher risk of target organ injury (TOI), including left ventricular hypertrophy (LVH) and adverse vascular remodeling [25]. These subclinical cardiovascular outcomes are consistently associated with increased risks of CVD and mortality among adults and are strong markers of early myocardial damage [8]. However, until recently there was limited direct evidence linking childhood HTN with definitive cardiovascular outcomes. Fortunately, recently published population-based studies are beginning to close these gaps (Fig. 1), showing higher long-term risks of cardiovascular and kidney outcomes among individuals with elevated BP identified in childhood [26,27].

### Cross-sectional cohort studies on intermediate markers of cardiovascular risk

Intermediate markers of preclinical organ damage are much more important in children and adolescents than in adults, as cardiovascular events are unlikely to occur for many years in young individuals. Robust evidence links elevated BP in children to subclinical TOI. LVH was shown in at least a fifth of untreated children with primary HTN [28]; a recent meta-analysis of 38 pediatric studies found higher odds of LVH (odds ratio, OR 4.69 [95% confidence interval, 95% CI, 2.69–8.19]) and greater left ventricular mass index, increased pulse wave velocity and increased carotid intima–media thickness among children with ambulatory HTN compared to normotensive children [29]. Similar findings have been reported when HTN is confirmed using office BP measurements [30]. These markers of TOI are well established precursors of adult CVD and mortality.

### Data from longitudinal cohort studies

In 2022, the International Childhood Cardiovascular Cohorts (i3C) Consortium reported the first data demonstrating direct associations between high SBP in childhood and the incidence of disease end-points (fatal cardiovascular event, or nonfatal myocardial infarction, stroke, transient ischemic attack, angina, ischemic heart failure, peripheral artery disease, carotid intervention, abdominal aortic aneurysm, or coronary revascularization) in mid-adulthood [31,32]. Children with BP higher than the 90th percentile had double the risk of a fatal or nonfatal mid-life event (mean age ~50 years), and this finding was consistent across childhood age from 4 to 19 years [32]. In absolute terms, about one in 10 children with ‘elevated BP’ or ‘HTN’ (defined via the AAP guideline) experienced a mid-life event, which increased to one in three in those with a combined risk score (incorporating BP, BMI, triglycerides,

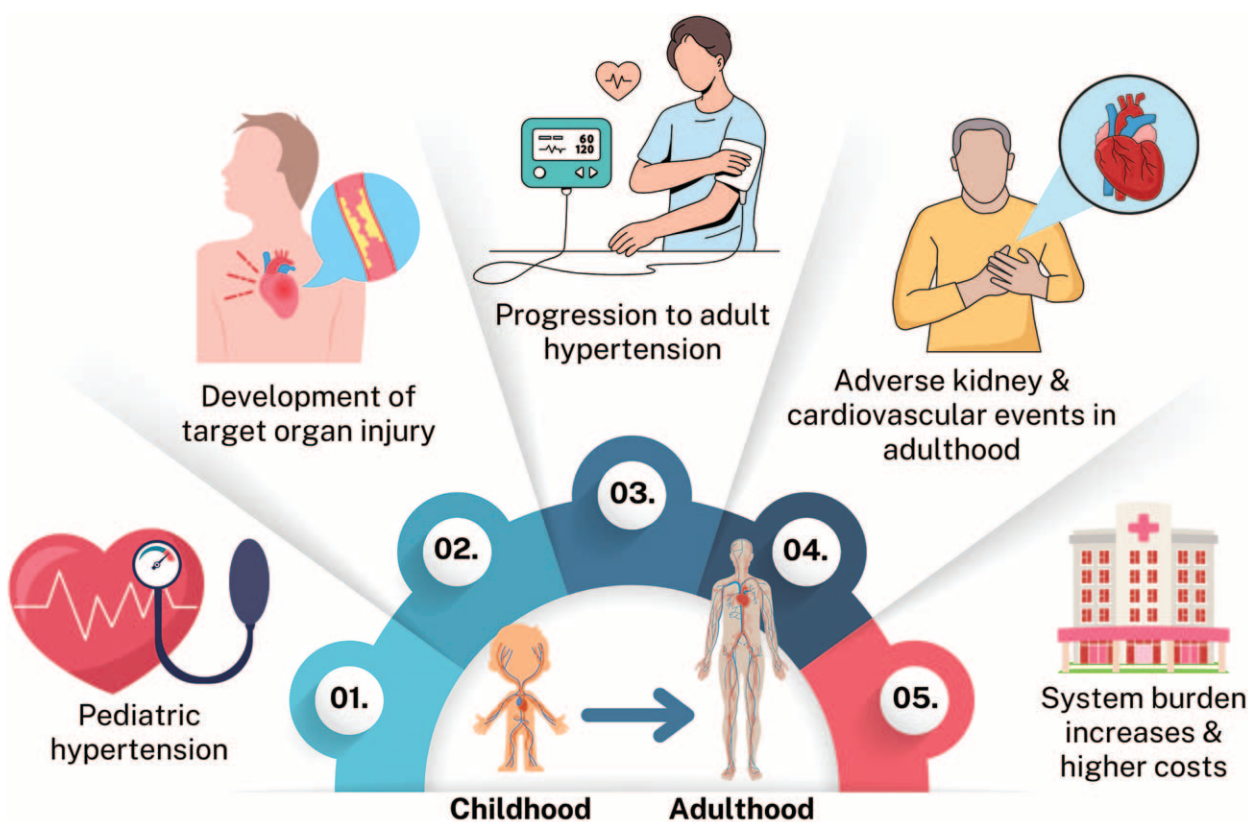


**Fig. 1** Life-course consequences of pediatric hypertension.

total cholesterol, and youth smoking) greater than the 90th percentile [31]. Further analysis suggested that 11% of the total risk related to high SBP was 'laid down' (i.e. a direct effect) in childhood (3–11 years), another 10% in adolescence (12–19 years), and the remaining 79% in adulthood [33]. These data are broadly consistent with findings from the Young Finns Study showing that the childhood years contribute almost 40% of the association between high SBP and atherosclerosis in mid-adulthood [34], highlighting the importance of system-level primordial prevention efforts and early intervention for children with elevated BP.

Recent population-based data from Ontario show that pediatric HTN confers a two-fold higher hazard of major adverse CV events over a median follow-up of 13.6 [35]. Using the same databases, hypertensive youth were also found to have threefold higher risk of major adverse kidney events (incident CKD, kidney failure, or death) [27]. Similarly, in a large cohort of Israeli military recruits, adolescent HTN (16–19 years old) was associated with an increased risk of developing chronic kidney disease, irrespective of BMI status or HTN severity [36]. Beyond clinical outcomes, hypertensive youth also incur greater health-system use and costs [37]. These results suggest that understanding how childhood-onset primary HTN develops, progresses throughout the lifespan, and contributes to kidney and heart disease burden has important public health and economic implications (Box 1).

**Box 1** Youth blood pressure and long-term outcomes

1. Childhood HTN causes early preclinical target-organ injury that predicts adult cardiovascular disease.
2. Longitudinal and population-based studies demonstrate progression from childhood high-normal/elevated BP and HTN to adult cardiovascular and kidney disease.

# BLOOD PRESSURE MEASUREMENT AND HYPERTENSION DIAGNOSIS

## Blood pressure devices and measurement methods

Accurate BP measurement is fundamental to diagnosis and management of HTN. Screening for HTN in youth should occur regularly, with more frequent screening recommended for those at greater risk for HTN (e.g., those with prematurity, kidney/urologic/cardiac disease, comorbid obesity, or diabetes mellitus) [2]. This screening initially occurs in the office setting, typically with an automated/oscillometric device [38]. According to current pediatric guidelines [1,2], elevated screening measurements (those greater than diagnostic thresholds) should be repeated by manual auscultation to confirm [39]. While several recent studies have shown little difference between average standardized oscillometric and auscultatory BP measurements in pediatric cohorts, these data have not yet found their way into the major pediatric clinical practice guidelines.

These recommendations have arisen from the fundamental differences in devices used for automated and manual BP measurement. Automated BP devices primarily use an oscillometric method to estimate BP. What this means is that the BP cuff senses arterial wall volume variations caused by the brachial pulse either during cuff inflation or deflation; the devices use the rise and fall in detected pulse amplitude (called the oscillogram) to then estimate the SBP and DBP via a proprietary algorithm. The algorithm differs between devices and therefore only the specific brand/make/model specific cuffs should be used with automated devices. Auscultatory devices, on the other hand, rely on audible Korotkoff sounds and operator skill to determine SBP and DBP. They do not require brand-specific cuffs so long as the size requirements discussed below are met.

Both types of devices need to undergo testing to determine accuracy prior to use. For automated devices, this means ensuring the device has undergone validation testing for accuracy [40] and, for aneroid devices, this means confirming the device has undergone recent calibration to ensure the mechanical components (metal bellows, gears, and levers) have not experienced drift or mispositioning [41].

Importantly, an automated device which passed validation testing in adults may not be accurate in children; separate validation testing is required for devices intended for use in children younger than 13 years of age [42]. Only devices which have been validated according to current standards in children should be used in this age group. Updated lists of properly validated devices for office, home and ambulatory BP measurement specifically for children are listed at the STRIDE BP website (www.stridebp.org/bp-monitors/), which operates in collaboration with the ISH, the ESH and the WHL. There are other regional or national registries providing lists of validated devices, for example, by the American Medical Association (validatebp.org), the British & Irish Hypertension Society (bihs.org.uk/blood_pressure_technology), and Hypertension Canada (hypertension.ca/public/recommended-devices). Unfortunately, very few automated BP devices have been successfully validated using an established protocol in children and are available on the market [43].

Even using a validated device, patient preparation and positioning is key for accuracy (Fig. 2). Unfortunately, poor standardization of BP measurement remains common in offices and clinics [44].

Lack of adherence to recommended BP measurement steps can lead to significant over- and underestimation of BP (Table 2). Of these necessary steps, selection of a correctly sized cuff is of paramount importance, as even compression of the artery is needed to obtain accurate measurements. Cuffs that are one and two sizes too small in adults have been shown to overestimate SBP by almost 10 and 20 mmHg, respectively [46]. Cuff selection should be guided by the child's measured mid-arm circumference (the midpoint between acromion and olecranon), choosing a cuff size per manufacturer recommendations for automated measurements or according to bladder dimensions for auscultatory measurements [2]. Wrist cuff devices and devices without a cuff (cuffless) are not recommended for BP measurement in children at present given the absence of validation. With auscultatory measurement, Korotkoff sounds phase I (onset of two consecutive taps during cuff deflation) and V (disappearance of sounds) are used to identify SBP and DBP, respectively. If the Korotkoff sounds can be heard down to zero, oftentimes it is because too

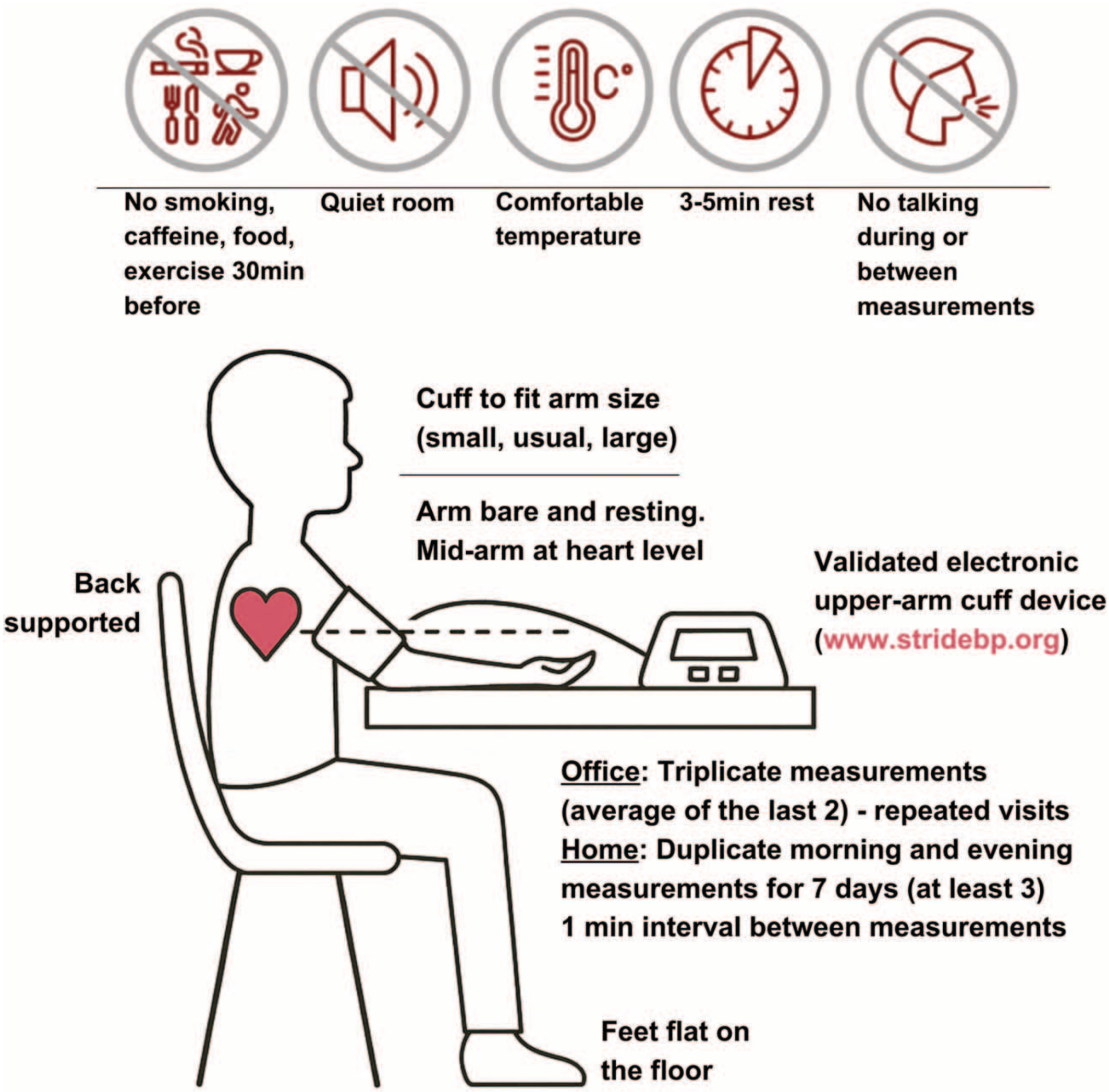


**Fig. 2** Recommended conditions and technique for accurate blood pressure measurement in children and adolescents.

much pressure has been applied over the brachial artery. In that case, it is best practice to repeat the measurement applying less pressure; alternatively, K4 can be reported as the diastolic value (1,33). Inflating the cuff to the peak inflation level is key, as insufficient inflation could allow the sounds occurring after the auscultatory gap to be confused as K1, resulting in an underestimation of BP. Peak inflation level is 20–30 mmHg above the point at which the radial pulse is obliterated during cuff inflation.

## Hypertension diagnosis and the importance of out-of-office blood pressure measurement

Hypertension is suspected when the average manual BP is elevated above diagnostic thresholds, over several visits, after which several additional steps are needed for confirmation. In children with suspected HTN, BP should be measured in both arms and one leg (see below) and then on at least two additional office visits. As mentioned earlier (Table 1), the threshold by which HTN should be suspected in children and adolescents varies by region, with percentile-based definitions used for younger children (<13 years in the US and Canada, <16 years in Europe) and static cut-points used for older patients (≥130/80 in the US and Canada, ≥140/90 in Europe) [51]. The intervals between the visits depend on the level of BP elevation, usually within weeks, or within days if BP values are suggestive of stage 2 HTN.

While HTN is most often diagnosed based on office/clinic BP measurements, out-of-office BP measurements also play an important role in the confirmation of HTN, as well as its chronic management. Out-of-office BP meaurements have superior reproducibility to office measurements and stronger association with indices of preclinical target-organ damage

**TABLE 2. Inaccuracies in blood pressure values caused by incorrect technique**

| Potential source of inaccuracy | Effect on SBP (mm Hg) | Effect on DBP (mm Hg) |
|---|---|---|
| Patient preparation | | |
| Acute meal ingestion | -6 | -5 to -1.9 |
| Acute alcohol ingestion | +23.6 to +24 | +1.4 to +4 |
| Acute caffeine consumption | +3 to +14 | +2.1 to +13 |
| Acute nicotine use or exposure (smoking, vaping, pouch) | +2.8 to +25 | +2 to +18 |
| Bladder distension | +4.2 to +33.0 | +2.8 to +18.5 |
| Insufficient rest period | +1.0 to +11.6 | +1.8 to +4.3 |
| Patient positioning/Room characteristics | | |
| Cold room | +5 to +32 | +4 to +23 |
| Public area | -0.7 to +0.1 | +1.45 to 1.65 |
| Arm unsupported | +3.9 to +6.5 | +2.7 to 4.8 |
| Mid-arm lower than heart level | +3.7 to 23 | +2.8 to +12 |
| Back unsupported | +0.7 to +2.3 | +1.8 to +6.5 |
| Legs crossed | +2.5 to 14.9 | +1.4 to +10.8 |
| Patient standing | -2.9 to +5 | +7 |
| Supine | -10.7 to +9.5 | -13.4 to +6.4 |
| Device and cuff characteristics | | |
| Device not calibrated | Variable | Variable |
| Too small cuff size | +2.1 to +19.5 | +1.6 to +7.4 |
| Too large cuff size | -1.0 to -6.5 | -1.0 to -5.0 |
| Measurement technique | | |
| Cuff placed over clothing | Not significant effects | Not significant effects |
| Stethoscope placed under cuff | +1.0 to +3.1 | -10.6 to -3.5 |
| Talking during measurement | +4 to +19 | +5 to +14.3 |
| Use of stethoscope bell | -3.8 to -1.5 | -1.6 |
| Excessive pressure on stethoscope | Not significant effects | -15 to -9 |
| Deflating cuff too fast (>3 mmHg/s) | -9 to -2.6 | +2.1 to +6.3 |
| Observer characteristics | | |
| Observer hearing deficit | -1.6 to -0.1 | +1.1 to +4.3 |
| Recording K4 vs. K5 for DBP | Not applicable | +12.5 |
| Relying on a single measurement | +3.3 to +10.4 | +2.4 to +5.1 |
| Terminal digit preference | 1% to 79% overrepresentation of terminal of 0 | 3% to 79% overrepresentation of terminal of 0 |

Adapted from Muntner *et al.* [45] and updated from [46–50].

[52]. Specific indications for out-of-office BP measurement are summarized in Table 3.

Twenty-four-hour ambulatory BP monitoring (ABPM) is the preferred modality for out-of-office measurement in children and adolescents. Despite wider availability of home BP monitoring (HBPM) both in high and low resource settings, in the pediatric population there is limited evidence on its accuracy, especially for diagnosis of HTN. Given this, home BP monitoring is only considered acceptable for monitoring and managing existing HTN in the United States and Canada [2,53,54], while in in Europe HBPM is additionally recommended for the diagnosis of HTN [1,55]. While there are emerging data on the clinical utility of HBPM in youth [56], larger studies of HBPM in children and adolescents are still needed in order to resolve these differening recommendations.

Twenty-four-hour ABPM requires specialized equipment and trained staff to initialize the monitor and download the data for interpretation, so children and adolescents should be referred to centers with expertise when pursuing ABPM. This method is considered the reference standard because it can provide 60–70 measurements during routine activities over a 24-h period, with wake and sleep measurement averages provided, allowing one to detect not just white-coat and masked HTN, but also nocturnal HTN and, dipping patterns, both of which contribute to CVD risk assessment [53,57]. For home BP, 5–7 days monitoring (no less than 3) is required, with duplicate morning and evening measurements to average 12–28 readings. ABPM is the reference method for assessing nocturnal HTN; yet novel low-cost automated HBPM devices may soon allow the evaluation of nocturnal BP profile with satisfactory agreement compared to ABPM [58]. As with office devices, ABPM and home BP monitors should be validated and used with appropriate brand-specific cuff sizes. The methodology for out-of-office BP monitoring is summarized in Table 4.

**TABLE 3. Clinical indications for out-of-office blood pressure monitoring (ambulatory or home[a])**

- Confirmation of hypertension diagnosis before treatment initiation, or investigation for secondary hypertension
- Suspected white-coat or masked hypertension
- Diagnostic disagreement between office and out-of-office blood pressure measurements
- Confirmation of resistant hypertension
- Evaluation of blood pressure control in treated children (home blood pressure)
- Assessment of nocturnal hypertension and nondipping (ambulatory blood pressure preferred)
- Special populations (diabetes mellitus, chronic kidney disease, severe obesity, sleep apnea, autonomic dysfunction, solid-organ transplant, repaired aortic coarctation)
- Assessment of symptoms suggesting hypotension.

[a]The research evidence is much stronger for using 24-h ambulatory than home blood pressure monitoring in children and therefore this method should be preferred when accessible and accepted by users.

**TABLE 4. Methodology for out-of-office blood pressure monitoring**

| |
|---|
| Ambulatory/home blood pressure monitoring |
| • Use of devices validated in children with appropriate cuff size |
| Ambulatory blood pressure monitoring |
| • Perform preferably on a routine school day |
| • Fit monitor on nondominant arm |
| • Measurements at 15–30 min intervals during the day and night |
| • At least 20 valid awake and 7 asleep BP readings required (70% valid measurements) |
| • Define awake/asleep blood pressure according to the individual's diary |
| Home blood pressure monitoring |
| • Measurements for 7 days (at least 3 days), preferably school days |
| • Before drug intake if treated and before meals |
| • Duplicate morning and evening measurements after 5 min rest with 1-min interval |

Office and ABPM can be combined to categorize the patient's BP phenotype, as summarized in Table 5. White-coat HTN – when BP is elevated solely in the office setting – in children and adolescents seems to be an intermediate CVD risk phenotype [59] that needs long-term follow up along with lifestyle modification. Masked HTN – when BP is solely elevated in the out-of-office setting – in children and adolescents has been associated with similar TOI and CVD risk as sustained HTN and may be an indication for echocardiography and pharmacological treatment initiation [59,60]. The risk of masked HTN is low in children with office BP levels less than 25th percentile [61], while it is higher in children with obesity and/or sleep apnea, as well as those with chronic kidney disease and coarctation of the aorta [62]. Diagnosis of both conditions needs repeated office and out-of-office BP measurements with ABPM being particularly important when masked HTN is manifested as isolated nocturnal HTN [53]. HBPM may also be used to detect masked HTN, although pediatric studies are limited.

# DIAGNOSTIC EVALUATION

## Targeted birth and medical history

Medical history is crucial when evaluating pediatric HTN. Because primary HTN, even in cases of pediatric onset, has a significant hereditary component, any history of HTN in first-degree relatives or early-onset CVD should be documented [63]. Birth and perinatal history should be carefully reviewed as both maternal conditions such as HTN or preeclampsia, and infant characteristics such as prematurity, small for gestational age status, or stay in a neonatal ICU have been associated with an increased risk of HTN [64]. Any history of renal disease or anomalies should be explored, since renal causes are the most common secondary cause of HTN in children [65]. For example, inquire about congenital anomalies of the kidney and urinary tract noted on prenatal ultrasound or any diagnosis of chronic kidney disease. Past medical history of severe illnesses or treatments (such as repaired coarctation of the aorta, cancer therapy, organ transplant, or prolonged corticosteroid use) should also be reviewed, as these can contribute to HTN and/or the risk of future clinical events.

**TABLE 5. Blood pressure phenotypes based on office and ambulatory measurements**

| | Ambulatory BP | Office BP |
|---|---|---|
| Normal blood pressure | Normal | Normal |
| Ambulatory hypertension | Elevated | Elevated |
| White coat hypertension | Normal | Elevated |
| Masked hypertension | Elevated | Normal |

## Key aspects of physical examination

A thorough physical examination should be performed, focusing on stigmata of conditions associated with HTN, and signs of hypertensive TOI. Height and weight should be measured and BMI calculated to assess for obesity or poor growth, since obesity often contributes to primary HTN and growth delay may indicate chronic disease. Once HTN is confirmed, BP should be measured in both arms and in the leg to check for discrepancies suggestive of coarctation. Clues to secondary HTN should be sought, for example, weak femoral pulses, low leg BP, or a murmur suggest coarctation; an abdominal mass or bruit may indicate a renal or renovascular cause; and unusual skin or facial features can point to a genetic or endocrine disorder known to be associated with HTN. Signs of HTN-induced target organ damage, such as retinal changes or cardiac strain, should be noted. Especially in children above the age of 6 years, the physical examination is typically normal in youth with HTN, apart from obesity which is common.

## Screening for secondary causes of hypertension

A sequential approach to screening for secondary causes of HTN is recommended by all major guidelines. This reflects the predominance of primary HTN in an unselected population of children presenting with HTN. Nevertheless, secondary causes are more common among children than adults with HTN, and the yield of further testing increases with reducing age and an increasing severity of HTN (Box 2) [63]. The 24-h BP phenotype also helps to stratify risk, a normal nocturnal BP making secondary HTN unlikely [66].

**Box 2** Indications for an extensive work-up

1. Age less <6 years
2. Age 6–12 years without obesity or HTN in parents
3. Stage II HTN in a child without obesity of any age
4. HTN accompanied by TOI
5. Severe acute HTN
6. Family history of secondary HTN
7. The presence of a syndrome associated with secondary HTN.

Table 6 outlines those tests that should be performed in all children with confirmed HTN and potential additional investigations for selected cases [67]. There is some divergence internationally on the inclusion of urinary tract ultrasound for all children vs. a selected population only. Similarly, echocardiography may not be necessary in all patients, and in some settings may need be prioritized depending on access to pediatric echocardiography.

The key to a targeted screening approach lies in appropriate patient selection. Tests such as those for Cushing syndrome or phaeochromocytoma and paraganglioma will overwhelmingly yield false-positive results in an unselected population. However, in a child with a faltering growth

**TABLE 6. Sequential evaluation of childhood hypertension**

| | |
|---|---|
| All children | Urea and electrolytes, serum calcium/magnesium/phosphate, serum creatinine<br>Urine dipstick[a] |
| | Renal tract ultrasound with Doppler[b] |
| | Echocardiography[b] |
| Risk stratification and detection of metabolic syndrome | Lipids |
| | HbA1c (plus fasting glucose in high-risk) |
| | Liver function tests (liver ultrasound in high-risk) |
| Consider based on history and examination, or any child with severe or difficult to control hypertension[e] | Plasma renin activity and serum aldosterone |
| | Thyroid function tests |
| | Urine or plasma metanephrines |
| | Cortisol testing – any of: low-dose dexamethasone suppression test, 24-h free urinary cortisol, and late-night salivary cortisol[c] |
| | Dimercaptosuccinic acid scan |
| | Cross sectional imaging or digital subtraction angiography[d] |
| | Sleep study |
| | Full blood picture |
| | Testing for monogenic disorders: genetics, urine and plasma steroid profile |
| | Inflammatory markers |
| | Drug screen |

[a]First morning urine protein-to-creatinine if dipstick $\geq$1+; dipstick not valid if urine specific gravity <1.005.
[b]If not routinely, then in young children (<6 years) and those being considered for pharmacotherapy.
[c]Urinary or salivary cortisol should be measured twice to minimize the impact of day-to-day variability.
[d]The latter being preferable when available and there is a high index of suspicion.
[e]Severe or difficult to control hypertension – any of: unexpected grade II hypertension, more than mild symptoms, hypertension not controlled on two or more medications.
Adapted from Larkins N and Roebuck D [67].

velocity or severe HTN, these tests may yield treatable causes that have broader implications for their health. Plasma renin activity (or direct renin concentration) is no longer recommended in all children as it is a poor predictor of renovascular disease. In the correct setting, on the other hand, a suppressed renin level can suggest monogenic causes of HTN, which mostly increase the activity of aldosterone and/or sodium resorption, leading to an appropriate physiologic reduction in renin. There has also been a change from measuring catecholamines directly to the use of metanephrines use of plasma metanephrines, which have a higher specificity compared to catecholamine measurement [68].

## Advanced diagnostics/target organ assessment

When treating children with HTN, assessment of HTN mediated preclinical TOI is essential. Decisions regarding the initiation of pharmacotherapy, drug class selection, and risk stratification all benefit from evaluating target organ damage. When abnormal or when there is uncertainty about treatment adequacy, sequential measurements can be helpful.

(1) Heart: Echocardiography is recommended. Left ventricular function, left ventricular mass (LVM), and its geometry should be assessed [1,2]. LVM should be calculated using the cube formula, indexed by height to yield the left ventricular mass index (LVMI) in $g/m^{2.7}$, and compared with age-appropriate percentiles. Simplified LVM thresholds for older children are also used, although there remains controversy about the optimal approach. [1].
(2) Kidneys: Urinalysis and assessment of estimated glomerular filtration rate should be performed. While abnormalities due to primary HTN are rare in childhood, these also assist in screening for renal parenchymal disease, which is the most common cause of secondary HTN in children.
(3) Blood vessels: Although reference values exist for carotid intima-media thickness and pulse wave velocity in children, routine assessment to stratify risk in hypertensive youth cannot be recommended; at present their use remains limited to research [1,2].
(4) Other tests, such as fundoscopy, are reserved for children with severe symptomatic HTN. Routine brain imaging is not recommended for asymptomatic children [1].

# THERAPY OF HYPERTENSION

## Efficacy of lifestyle measures as treatment of hypertension

Lifestyle modification is often the first step in managing pediatric HTN and is feasible in busy primary care settings worldwide. Before starting antihypertensive medications, among children with no significant comorbid conditions and asymptomatic stage 1 HTN, or in some cases, stage 2 HTN linked to obesity, a 6-month trial of nonpharmacological management is typically recommended [69]. However, drug therapy should not be delayed for a longer time if HTN persists. Notably, even when antihypertensive medications are initiated, maintaining lifestyle changes remains crucial for facilitating optimal BP control. This section briefly outlines practical, low-cost actions tailored to family culture, resources, and local environments. Where available, structured supports (e.g., dietitian-led counseling, school-based activity programs, mindfulness/yoga) can be added to enhance adherence (Fig. 3).

### Diet

In general, dietary patterns emphasizing fruits and vegetables, whole grains, legumes, nuts, and low-fat dairy (to increase potassium, magnesium, calcium, and fiber) and plant-based protein as well as reduced sodium consumption are helpful for the prevention and management of HTN in children and adolescents. An example is the DASH diet (Diet Approaches to Stop Hypertension), illustrated in Fig. 3, which has been shown to be an effective intervention for lowering BP in adolescents [70,71]. Several other healthy eating patterns, including Mediterranean or Nordic diets, can also have a beneficial effect on BP control in children and adolescents [72–74]. Implementation of healthy dietary habits in early childhood has shown long-term protective effects and improved adherence during adolescence [73].


**Fig. 3** Core lifestyle recommendations for the prevention and management of elevated blood pressure in children and adolescents.

Any dietary counseling should be tailored to the children's or adolescents' preferences, family culture, and socioeconomic context [75].

Dietary sodium intake remains a key, modifiable driver of elevated BP in youth [76,77]. The primary sources of sodium in children's diet are processed and ultra-processed foods as well as discretionary intake of table salt or other sodium-containing additives. Cultural food practices and regional cooking patterns also influence sodium sources, highlighting the need for culturally appropriate counseling [78]. Education should be provided to youth and their families regarding the amount of sodium in their primary sources of food, how to select lower sodium options, and the potential impact on their BP [79] Avoidance of sugar-sweetened beverages, which increase salt consumption and the risk of obesity [80], should also be recommended. In adolescents, a sodium intake of 2000 mg/day is recommended, whereas in younger children, sodium intake should be limited based on age-appropriate energy requirements. The adjustment of recommended sodium intake based on energy requirements is recommended because of the positive association between energy requirements and sodium intake. If country-specific data are not available, data from another country with similar population demographics and dietary habits can be used to make this adjustment.

## Physical activity

Individual and school-based physical activity is an important strategy for preventing and managing pediatric HTN [1]. A practical target is at least 60 min of moderate-to-vigorous aerobic exercise daily, such as brisk walking, jogging, cycling, swimming, or team, at least 3–5 days per week (30–60 min per session), depending on age group [1]. Regular physical activity has been shown to reduce SBP by 2–4 mmHg, especially in overweight or sedentary youth, while also contributing to obesity prevention [1,81]. High-intensity interval training programs are associated with small but significant reductions in both systolic and diastolic BP [82]. Combining physical activity with dietary or weight-loss programs had a significantly higher reduction in both SBP and DBP compared to diet-only or physical activity-only intervention [83]. There is a direct association between sedentary behavior and a high risk of HTN. Therefore, sedentary recreational screen time should be limited to 2 h per day [84]. additionally, school-based interventions, including structured physical activity programs, health education, active recess, and movement-friendly environments (e.g., "walking school buses"), are especially effective in lowering BP and promoting lasting behavioral change [84,85]. The only limitation to exercise participation is in patients with uncontrolled stage 2 HTN, who should be restricted from participation in competitive sports until their BP has been controlled (1).

### Stress reduction and sleep habits

Complementary medicine interventions have shown promising results for controlling BP in youth, especially those focusing on stress reduction [69]. Mind-body interventions such as mindfulness-based yoga, diaphragmatic deep breathing, and school-based relaxation curricula offer beneficial effects for children and adolescents at risk of HTN [2]. African–American adolescents practicing breathing awareness meditation experienced 4–5 mmHg reductions in both resting and ambulatory SBP after three months [86]. School-based yoga and mindfulness programs in adolescents (ages ~12–13 years) enhanced emotional regulation, coping, and concentration, psychological benefits that support BP control in pediatric context [87]. In younger children (ages 7–8 years), mindfulness-oriented meditation improved attention and internalizing behavior-stress mediators influencing cardiovascular function [88]. Diaphragmatic breathing interventions in children and teens (6–18 years) consistently reduced stress and anxiety by enhancing parasympathetic activity, which may lower sympathetic-driven BP increases [89]. Finally, there is growing evidence that short sleep duration is an additional risk factor for HTN [90]. Therefore, it is important to promote a healthy sleep duration according to the patient's age group [91].

### Weight management

As reviewed earlier, excess body weight is strongly associated with pediatric HTN [92]. Studies consistently show that dietary interventions promoting weight loss also improve BP and other cardiometabolic parameters [93]. Sustained weight reduction in children with overweight or obesity has been associated with SBP reductions of 7–10 mmHg [94]. In primary care, emphasis should be on specific, low-cost behaviors including dietary changes to reduce intake of high sodium, ultra-processed; aligning calorie intake with growth and activity; and improving physical activity while reducing sedentary time. Where feasible, dietitian-guided counseling, community or school-based activity programs can be added to improve adherence. Family engagement is key to achieving and sustaining a healthy weight in youth. For example, motivational interviewing and caregiver modeling, where parents adopt the same eating and activity patterns, are also effective in facilitating behavioral change [95]. Lifestyle changes are especially effective when they are tailored to cultural and socioeconomic contexts [96]. Other practical strategies include a supportive home environment, regular family meals, clear rules regarding snacks and portion sizes, and limiting sugar-sweetened beverages. Implementation of dietary and lifestyle changes can be challenging and requires a multidisciplinary team, including physicians, dietitians, social workers, psychologists, and nurses [69].

Key aspects of lifestyle approaches to HTN management are summarized in Box 3.

**Box 3** Lifestyle approaches to hypertension

1. For asymptomatic Stage 1 (and some obesity-related Stage 2) HTN, start with a 6-month trial of nonpharmacological care even when medications are used. Sustained lifestyle change remains essential.
2. Shift toward fresh, minimally processed, lower-sodium foods rich in potassium/magnesium/calcium/fiber; reduce ultra-processed items and sugary drinks. Use simple, culturally tailored strategies in any setting; add dietitian support where available.
3. Aim for $\geq$60 min/day of moderate-to-vigorous activity 3–5 days per week, and limit recreational screen time to $<$2 h/day. Sports participation is acceptable except in those with uncontrolled Stage 2 HTN; school-based activity offers additional advantage.
4. Promote consistent sleep based on age. Encourage participation in mindfulness/yoga programs when resources allow.
5. Emphasize caregiver modeling, motivational interviewing, and a supportive home food environment; add multidisciplinary and community/school programs where feasible.

## Implementation of lifestyle measures

### Family counseling and education

Implementation of heart healthy behaviors including healthy food choices, regular physical activity, proper sleep hygiene and avoidance of smoking and vaping should be emphasized at every pediatric clinic encounter. Because these are learned behaviors, successful implementation depends on early and consistent adoption, and outcomes are strengthened when youth observe adults modeling the same practices. For this reason, inclusion of other household members should be encouraged [97]. A notable feature of pediatric HTN is that it is typically asymptomatic which means there is often no physical cue to motivate heart-healthy lifestyle changes. Incorporating motivational interviewing (Table 7), assessing readiness for change, and identifying individual motivators (a youth's personal 'why') can foster greater engagement and buy-in and lead to greater success. Consideration of the child's developmental stage and family dynamics is critical. Any intervention will need to consider the local context, including pertinent social determinants of health such as food insecurity, well tolerated outdoor spaces, and access to schools

**TABLE 7. Motivational interviewing in pediatric patients**

| Process | Key elements | Adaptations for younger children | Adaptations for adolescents |
|---|---|---|---|
| Engaging | Build rapport; understand family values, context, and social determinants of health; explore how these constructs impact health behaviors and/or beliefs regarding nutrition or physical activity. | Engage parents/caregivers as primary partners; explore their concerns and motivations. | Establish direct rapport with the adolescent while still acknowledging family context. |
| Focusing | Collaboratively identify and prioritize specific behaviors for change; respect autonomy. | Focus on parent-driven priorities (e.g., healthy meals, routines); align with family decision-making authority. | Focus on adolescent's own goals (e.g., physical activity, diet choices), while incorporating family support. |
| Evoking | Use open-ended questions, supportive feedback, active listening with validating responses and concise summarizing to elicit intrinsic motivation. | Draw out parent motivation to model and support healthy behaviors; emphasize parental role in shaping environment. | Draw out adolescent's personal reasons for change; encourage self-expression and agency. |
| Planning | Develop practical, sustainable action steps with tools such as SMART goals and readiness rulers; tailor to developmental stage and family circumstances. | Plans center on family-wide strategies with parents reinforcing goals and monitoring progress. | Plans emphasize adolescent-led goal-setting, with parents providing reinforcement and accountability. |
| Rationale | Enhances engagement, respects autonomy, and fosters sustainable lifestyle change by leveraging intrinsic motivation rather than external directives. | Parent motivation drives behavior change; integration into anticipatory guidance is key. | Adolescent motivation drives change; integration into anticipatory guidance and obesity/hypertension management is key. |

Adapted from motivational interviewing and pediatric counseling best practices [95,96].

with physical education programs and free and reduced meal provisions. In youth, technology-based support such as smartphone apps can improve engagement in and adherence to lifestyle measures.

### Tools and resources for healthcare providers

Part of the challenge with implementing heart healthy lifestyle behaviors in children is that pediatric and/or family focused tools are fewer in number and more complicated than what is available for adults. Professional societies and others have worked to bridge this gap by offering online resources, phone applications, and short videos targeting pediatric patients and their families. Examples of some of these resources are provided in Table 8.

### Policy/public health implications

With the continuing increase in prevalence of children with HTN worldwide, it is imperative that efforts to treat pediatric HTN involve stakeholders beyond the usual medical system. Differences in policy and practice between countries have been barriers in improving HTN care, especially when encompassing additional risk factors such as obesity[98]. A survey of pediatric nephrologists across 54 countries found that while most respondents recommended lifestyle changes or a combination of lifestyle changes and medication as first line treatment for HTN, patient nonadherence was a significant barrier to control [99]. Lack of knowledge of the importance of treating HTN and patient reluctance towards treatment were highlighted as additional barriers. However, the infrastructure and resources to address these barriers were limited. The WHO recently outlined a global roadmap to address pediatric HTN [100]. Among the areas highlighted by the WHO was the need for improved guidance on lifestyle changes for youth and families and that guidance on HTN management should be context sensitive. Regional differences in diet and lifestyle habits should be considered so that recommendations are relevant to each patient population. The WHO also recommended piloting different models for HTN screening including the use of school-based approaches. Indeed, only 22% of children undergo HTN screening through school-based clinicians [99], so this may be a promising avenue to not only improve screening practices but also provide personalized guidance on lifestyle measures to treat HTN. Education should also extend beyond the patient to include families for a life-course approach.

## Medication therapy

Treatment with antihypertensive medication should be considered when the level of BP remains persistently elevated and resistant to improvement despite lifestyle interventions for more than 6–12 months. Exceptions to this would be patients presenting with hypertensive emergencies, symptomatic HTN, with comorbid diabetes mellitus or chronic kidney disease or established HTN mediated TOI; in such patients, medications should be initiated immediately. The decision to start medication treatment should not be based solely on the child's BP level, but additionally should take into consideration any comorbidities and the underlying cause in those with secondary HTN.

Regardless of management with antihypertensive medications and/or lifestyle modifications, the treatment goal recommended by the American Academy of Pediatrics (AAP) Clinical Practice Guideline is less than the 90th percentile in young children and less than 130/80 mmHg in adolescents at least 13 years old; whereas the ESH guideline recommends a goal of below the 95th percentile, or less than 140/90 in adolescents at least 16 years old. A lower target is encouraged by the AAP and European Society of Hypertension in those with diabetes mellitus and/or chronic kidney disease, especially if presenting with proteinuria [1,2].

**TABLE 8. Resources to support lifestyle change**

**Nutrition and diet changes**

| Resource | Type | Region | Description | Short Link |
|---|---|---|---|---|
| American Heart Association<br>“Why Should I Limit Sodium?” | Handout<br>- Education<br>- Practical tips<br>- How to learn more | USA | Illustrated guide explaining sodium limits and label reading for families. | https://tinyurl.com/AHA-sodium |
| Johns Hopkins University<br>“Salt Shakedown — How to Avoid Hidden Sodium at the Grocery Store” | Video<br>- Education<br>- Practical tips | USA | Video showing how to interpret sodium and sugar on labels using real examples. | https://tinyurl.com/4vjn7u2v |
| World Health Organization<br>Sodium Reduction | Fact Sheet<br>- Education<br>- Recommendations for children and adults | Global | Global guidance on reducing salt intake with population-level strategies. | https://tinyurl.com/WHO-Sodium |
| National Heart Lung and Blood Institute<br>DASH:<br>“Tips on What to Eat vs Limit” | Infographic<br>- Simple recommendations<br>- Available in English and Spanish | USA | Details foods you should focus on and foods you should avoid for dietary approaches to stop hypertension | https://tinyurl.com/DASH-Rec |
| National Heart Lung and Blood Institute<br>“DASH Eating Plan” | Web Resource<br>- Education<br>- Links<br>- Tools<br>- Recipes | USA | DASH eating plan resources for all ages and calorie intakes, with printable handouts and tools | https://tinyurl.com/5n7nxudc |
| Expanded Food and Nutrition Education Program<br>“Making Smart Drink Choices” | Handout<br>- Education<br>- Examples | USA | Information regarding recommended amounts of beverages (milk, juice, water) by age | https://tinyurl.com/DrinkingRight |
| Centers for Disease Control and Prevention<br>“Be Sugar Smart” | Infographic<br>- Education<br>- Practical tips | USA | Tip sheet with graphics describing main sources of added sugars and how to avoid them | https://tinyurl.com/CDCSugar |
| Food and Drug Administration<br>“The Nutrition Facts Label” | Web Resource<br>- Education<br>- Practical tips<br>- Video<br>- Links to learn more<br>- Spanish version | USA | Interactive website with video and links in English and Spanish to teach adults and children how to read a food label | https://tinyurl.com/FDA-label |
| United States Department of Agriculture<br>“Start Simple with MyPlate App” | Smart phone application<br>- Food tracking<br>- Goal focused<br>- Kid friendly with badges | USA | Website with links to smart phone app and instructional video | https://tinyurl.com/FDAApp |

**Physical activity**

| Resource | Type | Region | Description | Short link |
|---|---|---|---|---|
| Centers for Disease Control and Prevention<br>“Physical Activity Basics” | Web Resource<br>- Education<br>- Recommendations by age<br>- Links to learn more | USA | Activity recommendations by age with links for examples | https://tinyurl.com/CDCMovement |
| Johns Hopkins University<br>“How to Get a Good Workout in a Small Space” | Video<br>- Instructional for all fitness levels<br>- Links with tools | USA | Quick home-based video demonstrating kid-friendly activities suitable for small spaces. | https://tinyurl.com/JHUExercise |

**Sleep**

| Resource | Type | Region | Description | Short link |
|---|---|---|---|---|
| Centers for Disease Control and Prevention<br>Sleep Basics | Web Resource<br>- Education<br>- Recommendations by age<br>- Links to learn more | USA | Overview of sleep needs, importance, and healthy bedtime routines. | https://tinyurl.com/SleepBasics |
| National Heart Lung and Blood Institute<br>“Get Enough Good-Quality Sleep” | Web Resource<br>- Education<br>- Recommendations by age<br>- Video<br>- Booklet link<br>- Links to learn more | USA | Explains age-based sleep needs and strategies for improving sleep patterns. | https://tinyurl.com/bdfdwa78 |

| Smoking cessation | | | | |
|---|---|---|---|---|
| **Resource** | **Type** | **Region** | **Description** | **Short link** |
| Smokefree Teen | Web Resource<br>- Adolescent focused education<br>- Tools and Tips<br>- Links to apps, texting platforms, Instagram and how to learn more | USA | U.S. site offering interactive quit tools, text support, and motivational resources for teens. | https://teen.smokefree.gov/ |
| Centers for Disease Control and Prevention<br><br>"How to Help Adolescents Quit Smoking" | Handout<br>- Education for healthcare providers | USA | Clinical guidance and handout for supporting adolescent tobacco cessation. | https://tinyurl.com/TeenQuitSmoking |

| Stress management | | | | |
|---|---|---|---|---|
| **Resource** | **Type** | **Region** | **Description** | **Short link** |
| National Heart Lung and Blood Institute<br><br>"Manage Stress" | Web Resource<br>- Education<br>- Video<br>- Links to learn more | USA | Overview of stress effects on cardiovascular health and coping strategies. | https://tinyurl.com/NHLBIStress |
| Public Broadcasting Service<br><br>"Strategies for Managing Stress and Anxiety" | Web Resource<br>- Education<br>- Links to learn more | USA | Parent-oriented strategies for managing children's stress and anxiety. | https://tinyurl.com/PBSStress |
| Calm App | Smart phone application<br>- Education<br>- Tools<br>- Links to learn more | Global | Mindfulness and relaxation smart phone app offering guided meditations and sleep support. | www.calm.com |
| National Institute of Mental Health<br><br>"I'm So Stressed Out" | Infographic<br>- Education<br>- Tips<br>- Links to learn more | USA | Visual guide to recognizing and managing stress in youth. | https://tinyurl.com/AnxietyorStress |

Prior to 1997, most medications, including antihypertensives, were rarely studied in children. Following the Food and Drug Administration Modernization Act (1997) and European Medicines Agency legislation (2007) incentivizing pediatric clinical trials, more antihypertensives have been studied in children, although primarily the newer medications. Unfortunately, beyond reported effect on BP level these trials have limited data and are of short duration, exclude young age groups, and the majority are not placebo-controlled although may involve a placebo washout phase [101]. Fortuitously, a systematic analysis of antihypertensive trial data showed that all the studied classes of drugs [angiotensin-converting enzyme (ACE) inhibitors, angiotensin receptor blockers (ARB), calcium channel blockers, and beta-blocker/diuretic] reduced BPs by a similar amount in children (~10.7 mmHg) [102]. In clinical practice, the most prescribed medications are ACE inhibitors followed by calcium channel blockers, and less frequently beta-blockers and diuretics [103]. The AAP Clinical Practice Guideline recommends initial monotherapy with an ACE inhibitor, ARB, long-acting calcium channel blocker, or a thiazide diuretic [2]. Hypertension Canada Guidelines are similar, although do not include diuretics as an initial therapy option due to a lack of trial data in children [101]. The AAP notes that due to the compensatory salt and water retention following treatment with many antihypertensive drugs, thiazide diuretics may be a preferred second agent when needed. The ESH pediatric guidelines suggest consideration of any of the antihypertensive classes studied in adults, and also recognize that, when possible, the antihypertensive may be matched to the etiology or pathophysiology of the HTN or an associated condition.[1]. Boxes 4 and 5 provide practical antihypertensive medication prescribing tips and specific drug considerations for comorbid conditions.

**Box 4** Antihypertensive medication prescribing tips

| Tip | Example |
|---|---|
| Try to match the drug to the mechanism of the hypertension if known | Use ACE inhibitors or ARBs for renal scarring (also see Box 2) |
| Try to use once or twice daily drugs to improve adherence | If using an ACE inhibitor, ARB, or CCB consider long-acting agents (once daily) |
| Try to avoid drugs that could exacerbate undesirable symptoms | Avoid beta-blockers in children with asthma or high-performance athletes |
| Try to pick drugs with desirable side effect profiles if possible | Consider calcium channel blockers in hypertensive children who also have Raynaud's |
| When multiple medications are required to reach goal BP, consider single-pill combinations to improve adherence. | Choose agents that exist in single-pill combination formulations (ARB/CCB, ACE inhibitor/diuretic) |

ACE, angiotensin-converting enzyme; ARB, angiotensin receptor blocker; CCB, calcium channel blocker.

**Box 5** Clinical conditions and antihypertensive medication considerations

| ACEi/ARB | Beta-blocker |
|---|---|
| • Chronic kidney disease<br>• Renal Scarring<br>• Proteinuria<br>• Diabetes Mellitus<br>• Obesity<br>• Dilated aortic root | • Migraine headache<br>• Repaired aortic coarctation<br>• Stable heart failure<br>• Hyperthyroidism |
| **Calcium Channel blocker** | **Diuretics** |
| • Migraine headache<br>• Raynaud's Syndrome | • Glomerulonephritis<br>• Chronic lung disease<br>• Edema<br>• Heart Failure |

ACEi, angiotensin-converting enzyme inhibitor; ARB, angiotensin receptor blocker.

In general, the antihypertensive can be started at the lowest treatment dose and increased if needed every 3–4 weeks or at an appropriate follow-up interval, while monitoring for potential side effects (e.g., orthostatic dizziness with all, cough with ACE inhibitors, ankle/leg edema with calcium channel blockers). Referral to a pediatric HTN specialist should be considered if the practitioner is uncomfortable with antihypertensive therapy prescribing or a secondary cause of HTN is identified.

When antihypertensive medication is indicated, prescribing practices should include consideration of other comorbidities, not just for avoidance of adverse reactions, but for potential added benefits (renoprotection, headache management, etc. [Box 5]) which may facilitate buy-in and adherence. Shared decision making, when possible, and review of dosing schedules and strategies to help with consistent administration may empower patients and families to take ownership of this aspect of their care. Discussions regarding optimal medication timing (regular time every day in the morning, or evening, during school day), use of visual cues and alarms, calendar reminders for medication refills, how to handle missed doses can all help with adherence.

## Long-term monitoring and transition to adult care

Long term monitoring of HTN in children and adolescents would need visits depending on BP stage, and presence of HMOD. More frequent regular visits and re-assessment of HMOD may be needed in case of pharmacological treatment and/or uncontrolled HTN. Out-of-office BP monitoring would be ideally performed especially following initiation of or modification of antihypertensive medications. HBPM is more commonly used in this phase of care, with time for adequate teaching, correlation between home and clinic devices and ABPM in each patient. A key advantage of HBPM is that the lower burden of care facilitates more frequent out-of-office BP measurement compared to ABPM, which remains the reference standard but is less practical at short intervals. Assessment of hypertensive TOI would be considered at least annually in those children and adolescents who were found to have it at the time of their HTN diagnosis. In adolescents, follow-up visits should also include also assessment for transition to adult care. A suggested approach to long-term management is outlined in Box 6.

**Box 6** Follow-up of the youth with hypertension

1. Once BP control achieved, schedule follow-up appointments every 4–6 months for those with CKD or diabetes and every 6–12 months for those with no comorbidities. Review progress with lifestyle measures as well as medication adherence.
2. Encourage HBPM 1–2 times/month, and twice daily for 3–5 days prior to each follow-up appointment. All families should be provided with a validated home BP monitor if medications are prescribed.
3. Laboratory monitoring to assess for medication toxicities (electrolyte disturbances, transaminase elevations, leukopenia, etc.) 1–2 times per year.
4. Reassess TOI by repeat echocardiography, etc. if abnormal at initial assessment.
5. Obtain repeat ABPM (if available) for questionable BP control based on home readings or progression of TOI despite treatment. Obtain repeat ABPM every 1–2 years in all patients with CKD.

Adolescence is a critical period with unique challenges, particularly in the presence of chronic health conditions [104]. Transitioning children with HTN into adult services is fraught with complications that can result in disengagement with healthcare services and poor clinical outcomes [105]. Treatment adherence is frequently poor after transfer to adult care. Among hypertensive young adults, adherence rates to medication have been reported low [106] with poor medication adherence has associating with higher risk for future CVD events at midlife [106]. Optimizing transition into adult services, by improving adolescent health programs [107], can mitigate these issues.

Adolescents cite logistical and psychosocial issues as contributors to challenges transitioning into adult services. Specific concerns raised include an attachment to pediatric care givers making them reluctant to leave pediatric services; fear of the adult system; concern for a decline in quality of care; and worry that adult providers will lack knowledge of their disease or personal medical history [108]. A sense of self-worth may be lacking in young people with chronic disease and there may be anxiety around physical capabilities, adding to the concerns that young people feel need to be addressed during the transition period [109].

Adolescents have identified themes that may improve the chances of successful transition into adult services. These include means to improve self-confidence; maintaining social connections; ensuring positive environments; boundaries in relationships between healthcare providers, parents or guardians and the adolescents; and avoiding the perception of ill-health [110]. Coordinated healthcare transition processes have been developed to empower adolescents and have in improved outcomes [108]. Different countries transfer adolescents into adult healthcare services at different ages, so transition models need to be flexible and to account for differences in available resources.

Transition process should ideally start early, at the age of 12–14 years in children with early onset HTN. Children and adolescents should be involved in discussions during medical visits, especially regarding medications and lifestyle modifications. In areas where a strict pediatric age limit of 18 years does not apply, the transfer to the adult clinic can be individualized depending on the adolescent's readiness and maturity. Key elements of readiness may include knowledge and understanding of disease and related treatment (lifestyle and/or drug treatment, importance of BP control), as well as appropriate medical self-management skills (managing medications, appointment keeping, ability to recognize and report health issues). Several smartphone apps have been developed to support self-management and transition to adult care; early data suggest these may be helpful if utilized consistently [111,112].

The timing of transfer should be a stable period both in disease and life (without diagnostic and therapeutic challenges, family or social life crisis). Combined adult and pediatric clinics, wherever feasible, may facilitate medical information allocation and encourage decision sharing, and avoid unnecessary changes in treatment after transfer that may increase anxiety and impair adherence. Close follow up for adherence to treatment and possible adverse outcomes before and after transfer to adult health units is needed. Adult HTN units with experience in rare causes of HTN would be ideal or may be needed for some hypertensive adolescents. Components of structured models for transition are summarized in Box 7.

**Box 7** Structured models for transition

1. Adult clinicians attending pediatric services; Pediatric clinicians attending adult health services (where feasible).
2. Dedicated adolescent services allowing intermingling of young patients with different conditions.
3. Flexibility with age of attendance (extending up to 25 years) allowing mingling with older patients still being followed by the pediatric provider.
4. Time slots that can accommodate usual school activities
5. Multidisciplinary teams including social workers, psychologists, nurses, clinicians and dietitians.
6. Progressive introduction of appointments without parents at individualized pace.
7. Flexible transition which may require reverse transmission
8. Peer mentoring, group appointments and discussions

## CONCLUSION

HTN in children and adolescents is no longer a rare or incidental finding, but a growing global health concern with profound implications for cardiovascular and kidney health across the life course. Early recognition, accurate evaluation, and effective management of elevated blood pressure in youth are essential to prevent TOI and reduce the burden of adult CVD. Over the past several decades, a number of guidelines have been developed to address pediatric HTN. While these provide valuable frameworks, their variability in definitions, thresholds, and recommendations has often complicated clinical practice, particularly in LMICs where resources are limited and context-specific adaptations are urgently needed. This underscores the importance of practical and harmonized approaches that can be applied across diverse health systems, ensuring that children everywhere receive timely and effective care.

This ISH position paper offers a pragmatic guide to support clinicians in navigating these complexities. By emphasizing accurate blood pressure measurement, thoughtful diagnostic evaluation, and stepwise management strategies, including lifestyle modification and pharmacotherapy when indicated, we provide this resource that is both evidence-based and adaptable to different settings. Ultimately, tackling HTN in youth requires not only clinical vigilance but also coordinated public health strategies, family engagement, and policy support. A unified commitment to early detection and effective management will be critical to mitigate the global rise in HTN.

## ACKNOWLEDGEMENTS

None.

### Conflicts of interest

JTF reports receiving a stipend from the International Peniatric Nephrology Association and royalties from Up To Date.

AK participated in several validation studies funded by manufacturers of blood pressure measurement technologies with payments to the Athens University Special Account for Research Grants.

AT reports receiving grant support from Inozyme Pharma and is the recipient of funding from the PEDSnet Scholars Program.

GS received lecture and consulting fees from several manufacturers of blood pressure measuring technologies, and conducted clinical development and validation studies with payments to the Athens University Special Account for Research Grants.

All other authors have no conflicts to declare.

## REFERENCES

1. Lurbe E, Agabiti-Rosei E, Cruickshank JK, Dominiczak A, Erdine S, Hirth A, *et al.* 2016 European Society of Hypertension guidelines for the management of high blood pressure in children and adolescents. *J Hypertens* 2016; 34:1887–1920.
2. Flynn JT, Kaelber DC, Baker-Smith CM, Blowey D, Carroll AE, Daniels SR, *et al.* Clinical practice guideline for screening and management of high blood pressure in children and adolescents. *Pediatrics* 2017; 140: e20171904.
3. 2018 Chinese Guidelines for Prevention and Treatment of Hypertension-a report of the Revision Committee of Chinese Guidelines for Prevention and Treatment of Hypertension. *J Geriatr Cardiol* 2019; 16:182–241.
4. Umemura S, Arima H, Arima S, Asayama K, Dohi Y, Hirooka Y, *et al.* The Japanese Society of Hypertension Guidelines for the Management of Hypertension (JSH 2019). *Hypertens Res* 2019; 42:1235–1481.
5. Rabi DM, McBrien KA, Sapir-Pichhadze R, Nakhla M, Ahmed SB, Dumanski SM, *et al.* Hypertension Canada's 2020 Comprehensive Guidelines for the Prevention, Diagnosis, Risk Assessment, and Treatment of Hypertension in Adults and Children. *Can J Cardiol* 2020; 36:596–624.
6. Consenso Argentino de Hipertensión Arterial 2025 [Argentine Consensus on Arterial Hypertension 2025]. *Rev Fed Argentina Cardiol* 2025; 54:5–64.
7. Genovesi S, Parati G, Giussani M, Bona G, Fava C, Maffeis C, *et al.* *High Blood Press Cardiovasc Prev* 2020; 27:183–193.
8. Jones DW, Ferdinand KC, Taler SJ, Johnson HM, Shimbo D, Abdalla M, *et al.* 2025 AHA/ACC/AANP/AAPA/ABC/ACCP/ACPM/AGS/AMA/ASPC/NMA/PCNA/SGIM Guideline for the Prevention, Detection, Evaluation and Management of High Blood Pressure in Adults: a report of the American College of Cardiology/American Heart Association Joint Committee on Clinical Practice Guidelines. *Hypertension* 2025; 82:e212–e316.
9. Ruan X, Zhu A, Wang T, Sun M, Chen K, Luo M, *et al.* Global prevalence of hypertension in children and adolescents younger than 19 years: a systematic review and meta-analysis. *JAMA Pediatr* 2025; 179 9:987–999.

10. Song P, Zhang Y, Yu J, Zha M, Zhu Y, Rahimi K, *et al.* Global prevalence of hypertension in children: a systematic review and meta-analysis. *JAMA Pediatr* 2019; 173:1154–1163.
11. Jeong SI, Kim SH. Obesity and hypertension in children and adolescents. *Clin Hypertens* 2024; 30:23.
12. Su S, Wang X, Pollock JS, Treiber FA, Xu X, Snieder H, *et al.* Adverse childhood experiences and blood pressure trajectories from childhood to young adulthood: the Georgia stress and Heart study. *Circulation* 2015; 131:1674–1681.
13. Hu J, Yang YD. Editorial: dietary and lifestyle factors associated with hypertension among children and adolescents. *Front Pediatr* 2023; 11:1212385.
14. Elsahoryi NA, Neville CE, Patterson CC, Linden GJ, Moitry M, Biasch K, *et al.* Association between overall fruit and vegetable intake, and fruit and vegetable sub-types and blood pressure: the PRIME study (Prospective Epidemiological Study of Myocardial Infarction). *Br J Nutr* 2021; 125:557–567.
15. Oladele CR, Khandpur N, Johnson S, Yuan Y, Wambugu V, Plante TB, *et al.* Ultra-processed food consumption and hypertension risk in the REGARDS Cohort Study. *Hypertension* 2024; 81 12:2520–2528.
16. Farhangi MA, Fathi Azar E, Manzouri A, Rashnoo F, Shakarami A. Prolonged screen watching behavior is associated with high blood pressure among children and adolescents: a systematic review and dose-response meta-analysis. *J Health Popul Nutr* 2023; 42:89.
17. Gangwisch JE, Heymsfield SB, Boden-Albala B, Buijs RM, Kreier F, Pickering TG, *et al.* Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. *Hypertension* 2006; 47:833–839.
18. Kato M, Phillips BG, Sigurdsson G, Narkiewicz K, Pesek CA, Somers VK. Effects of sleep deprivation on neural circulatory control. *Hypertension* 2000; 35:1173–1175.
19. Lusardi P, Zoppi A, Preti P, Pesce RM, Piazza E, Fogari R. Effects of insufficient sleep on blood pressure in hypertensive patients: a 24-h study. *Am J Hypertens* 1999; 12:63–68.
20. Meer R, Boateng D, Klipstein-Grobusch K, Norris SA, Kagura J. Incidence and correlates of high blood pressure from childhood to adulthood: the Birth to Twenty study. *J Hypertens* 2022; 40:274–282.
21. Jafar TH, Qadri Z, Islam M, Hatcher J, Bhutta ZA, Chaturvedi N. Rise in childhood obesity with persistently high rates of undernutrition among urban school-aged Indo-Asian children. *Arch Dis Child* 2008; 93:373–378.
22. Jafar TH, Islam M, Poulter N, Hatcher J, Schmid CH, Levey AS, *et al.* *Circulation* 2005; 111:1291–1297.
23. Visentin S, Grumolato F, Nardelli GB, Di Camillo B, Grisan E, Cosmi E. Early origins of adult disease: low birth weight and vascular remodeling. *Atherosclerosis* 2014; 237:391–399.
24. Chaturvedi A, Zhu A, Gadela NV, Prabhakaran D, Jafar TH. Social determinants of health and disparities in hypertension and cardiovascular diseases. *Hypertension* 2024; 81:387–399.
25. Robinson CH, Chanchlani R. High blood pressure in children and adolescents: current perspectives and strategies to improve future kidney and cardiovascular health. *Kidney Int Rep* 2022; 7:954–970.
26. Freedman AA, Perak AM, Ernst LM, Borders A, Miller GE, Allen NB, *et al.* High blood pressure in childhood and premature cardiovascular disease mortality. *JAMA* 2025; 334:1555–1557.
27. Hussain J, Georgieva K, Robinson CH, Jeyakumar N, Smith G, Brady T, *et al.* Long-term kidney outcomes in children and adolescents with hypertension: a propensity-matched cohort study. *Lancet Child Adolesc Health* 2025; 9:553–564.
28. Sinha MD, Azukaitis K, Sladowska-Kozłowska J, Bårdsen T, Merkevicius K, Karlsen Sletten IS, *et al.* Prevalence of left ventricular hypertrophy in children and young people with primary hypertension: meta-analysis and meta-regression. *Front Cardiovasc Med* 2022; 9:993513.
29. Chung J, Robinson CH, Yu A, Bamhraz AA, Ewusie JE, Sanger S, *et al.* Risk of target organ damage in children with primary ambulatory hypertension: a systematic review and meta-analysis. *Hypertension* 2023; 80:1183–1196.
30. Yang L, Magnussen CG, Yang L, Bovet P, Xi B. Elevated blood pressure in childhood or adolescence and cardiovascular outcomes in adulthood: a systematic review. *Hypertension* 2020; 75:948–955.
31. Jacobs DR Jr, Woo JG, Sinaiko AR, Daniels SR, Ikonen J, Juonala M, *et al.* Childhood cardiovascular risk factors and adult cardiovascular events. *N Engl J Med* 2022; 386:1877–1888.
32. Haley J, Woo JG, Jacobs DR Jr, Bazzano L, Daniels S, Dwyer T, *et al.* A clinical tool to relate youth risk factors to adult cardiovascular events and Type 2 diabetes: the International Childhood Cardiovascular Cohort Consortium. *J Pediatr* 2025; 276:114277.
33. Kartiosuo N, Raitakari OT, Juonala M, Viikari JSA, Sinaiko AR, Venn AJ, *et al.* Cardiovascular risk factors in childhood and adulthood and cardiovascular disease in middle age. *JAMA Netw Open* 2024; 7: e2418148.
34. Meng Y, Koskinen JS, Thomson R, Juonala M, Pahkala K, Mykkänen J, *et al.* Blood pressure in childhood, young- and mid-adulthood: association with carotid plaque severity. *Eur Heart J* 2025; 46: 2306–2316.
35. Robinson CH, Hussain J, Jeyakumar N, Smith G, Birken CS, Dart A, *et al.* Long-term cardiovascular outcomes in children and adolescents with hypertension. *JAMA Pediatr* 2024; 178:688–698.
36. Leiba A, Fishman B, Twig G, Gilad D, Derazne E, Shamiss A, *et al.* Association of adolescent hypertension with future end-stage renal disease. *JAMA Intern Med* 2019; 179:517–523.
37. Hussain J, Ahmed R, Robinson CH, Jeyakumar N, Smith G, Brady TM, *et al.* Healthcare resource utilisation and costs associated with hypertension in children and adolescents: a population-based cohort study. *Lancet Reg Health Am* 2025; 48:101157.
38. Jones L, Park J, Blair J, Hawcutt DB, Lip GYH, Shantsila A. 20 years on - the measurement of blood pressure and detection of hypertension in children and adolescents: a national descriptive survey. *J Hum Hypertens* 2023; 37:1086–1090.
39. Lurbe E, Regueiro-Ons C, Mancia G, Düzova A, Erdine S, Herceg-Cavrak V, *et al.* Blood pressure values in healthy normal weight children and adolescents in eight European countries: auscultatory and oscillometric measurements. *Eur J Intern Med* 2025; 139:106382.
40. Picone DS, Padwal R, Stergiou GS, Cohen JB, McManus RJ, Eckert S, *et al.* How to find and use validated blood pressure measuring devices. *J Hum Hypertens* 2023; 37:108–114.
41. John O, Campbell NRC, Brady TM, Farrell M, Varghese C, Velazquez Berumen A, *et al.* The 2020 "WHO Technical Specifications for Automated Non-Invasive Blood Pressure Measuring Devices With Cuff". *Hypertension* 2021; 77:806–812.
42. Stergiou GS, Alpert B, Mieke S, Asmar R, Atkins N, Eckert S, *et al.* A universal standard for the validation of blood pressure measuring devices: association for the advancement of medical instrumentation/European Society of Hypertension/International Organization for Standardization (AAMI/ESH/ISO) Collaboration Statement. *Hypertension* 2018; 71:368–374.
43. Stergiou G MA, Palatini P, Parati G, Wang J, Mariglis D, Schutte A, Kollias A. Validated automated cuff devices for children: STRIDE BP report & call to action. *Hypertension* 2025.
44. Setjiadi D, Geddes C, Delles C. Blood pressure measurement technique in clinical practice in the NHS Greater Glasgow and Clyde. *J Hum Hypertens* 2025; 39:205–209.
45. Muntner P, Einhorn PT, Cushman WC, Whelton PK, Bello NA, Drawz PE, *et al.* Blood pressure assessment in adults in clinical practice and clinic-based research: JACC Scientific Expert Panel. *J Am Coll Cardiol* 2019; 73:317–335.
46. Ishigami J, Charleston J, Miller ER 3rd, Matsushita K, Appel LJ, Brady TM. Effects of cuff size on the accuracy of blood pressure readings: the Cuff(SZ) randomized crossover trial. *JAMA Intern Med* 2023; 183: 1061–1068.
47. Ishigami J, Liu H, Zhao D, Sabit A, Pathiravasan CH, Charleston J, *et al.* Effects of noise and public setting on blood pressure readings: a randomized crossover trial. *Ann Intern Med* 2025; 178:149–156.
48. Liu H, Zhao D, Sabit A, Pathiravasan CH, Ishigami J, Charleston J, *et al.* Arm position and blood pressure readings: the ARMS crossover randomized clinical trial. *JAMA Intern Med* 2024; 184:1436–1442.
49. Wan TX, Wu YH, Wu YQ, Hu W, Su H. Differences in oscillometric blood pressure readings between unsupported and supported back conditions. *Hypertens Res* 2021; 44:528–532.
50. Ringrose JS, Wong J, Yousefi F, Padwal R. The effect of back and feet support on oscillometric blood pressure measurements. *Blood Press Monit* 2017; 22:213–216.
51. Brady TM, Stefani-Glücksberg A, Simonetti GD. Management of high blood pressure in children: similarities and differences between US and European guidelines. *Pediatr Nephrol* 2019; 34:405–412.
52. Zeniodi ME, Ntineri A, Kollias A, Servos G, Moyssakis I, Destounis A, *et al.* Home and ambulatory blood pressure monitoring in children,

adolescents and young adults: comparison, diagnostic agreement and association with preclinical organ damage. *J Hypertens* 2020; 38: 1047–1055.
53. Puthukara A, Kumar A, Bhatt GC, Maheshwari M, Pakhare AP, Malik S, *et al.* Performance of home-based and ambulatory blood pressure monitoring in obese children and their correlation with end organ damage. *Am J Hypertens* 2024; 37:561–570.
54. Xi B, Bovet P, Hong YM, Zong X, Chiolero A, Kim HS, *et al.* Recent blood pressure trends in adolescents from China, Korea, Seychelles and the United States of America, 1997-2012. *J Hypertens* 2016; 34: 1948–1958.
55. Stergiou GS, Palatini P, Parati G, O'Brien E, Januszewicz A, Lurbe E, *et al.* 2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement. *J Hypertens* 2021; 39:1293–1302.
56. Stergiou G, Stambolliu E, Bountzona I, Ntineri A, Kollias A, Vazeou A, *et al.* Home blood pressure monitoring in children and adolescents: systematic review of evidence on clinical utility. *Curr Hypertens Rep* 2019; 21:64.
57. Flynn JT, Urbina EM, Brady TM, Baker-Smith C, Daniels SR, Hayman LL, *et al.* Ambulatory blood pressure monitoring in children and adolescents: 2022 Update: a scientific statement from the American Heart Association. *Hypertension* 2022; 79:e114–e124.
58. Stambolliu E, Kollias A, Bountzona I, Ntineri A, Servos G, Vazeou A, *et al.* Nighttime home blood pressure in children: association with ambulatory blood pressure and preclinical organ damage. *Hypertension* 2021; 77:1877–1885.
59. Stabouli S, Kotsis V, Toumanidis S, Papamichael C, Constantopoulos A, Zakopoulos N. White-coat and masked hypertension in children: association with target-organ damage. *Pediatr Nephrol* 2005; 20: 1151–1155.
60. Lurbe E, Torro I, Alvarez V, Nawrot T, Paya R, Redon J, *et al.* Prevalence, persistence, and clinical significance of masked hypertension in youth. *Hypertension* 2005; 45:493–498.
61. Mitsnefes MM, Pierce C, Flynn J, Samuels J, Dionne J, Furth S, *et al.* Can office blood pressure readings predict masked hypertension? *Pediatr Nephrol* 2016; 31:163–166.
62. Seeman T, Šuláková T, Stabouli S. Masked hypertension in healthy children and adolescents: who should be screened? *Curr Hypertens Rep* 2023; 25:231–242.
63. Nugent JT, Jiang K, Funaro MC, Saran I, Young C, Ghazi L, *et al.* Does this child with high blood pressure have secondary hypertension? The rational clinical examination systematic review. *JAMA* 2023; 329: 1012–1021.
64. Larkins NG, Teixeira-Pinto A, Kim S, Burgner DP, Craig JC. The population-based prevalence of hypertension and correlates of blood pressure among Australian children. *Pediatr Nephrol* 2019; 34: 1107–1115.
65. Ding FL, Elias I, Wright R, De Mello A, Cojocaru D, Dionne J. Yield of diagnostic testing in evaluating etiology and end organ effects of pediatric hypertension. *Pediatr Nephrol* 2024; 39:513–519.
66. Flynn JT. Differentiation between primary and secondary hypertension in children using ambulatory blood pressure monitoring. *Pediatrics* 2002; 110:89–93.
67. Larkins N, Roebuck D. Diagnostic evaluation of pediatric hypertension. In: Flynn JT, Ingelfinger JR, Brady TM, editors. Pediatric hypertension. Cham: Springer International Publishing; 2023. pp. 755–770.
68. Christensen TT, Frystyk J, Poulsen PL. Comparison of plasma metanephrines measured by a commercial immunoassay and urinary catecholamines in the diagnosis of pheochromocytoma. *Scand J Clin Lab Invest* 2011; 71:695–700.
69. Lobitz CA, Yamaguchi I. Lifestyle interventions for elevated blood pressure in childhood-approaches and outcomes. *Curr Hypertens Rep* 2022; 24:589–598.
70. Couch SC, Saelens BE, Khoury PR, Dart KB, Hinn K, Mitsnefes MM, *et al.* Dietary approaches to stop hypertension dietary intervention improves blood pressure and vascular health in youth with elevated blood pressure. *Hypertension* 2021; 77:241–251.
71. Paula Bricarello L, Poltronieri F, Fernandes R, Retondario A, de Moraes Trindade EBS, de Vasconcelos FAG. Effects of the Dietary Approach to Stop Hypertension (DASH) diet on blood pressure, overweight and obesity in adolescents: a systematic review. *Clin Nutr ESPEN* 2018; 28:1–11.
72. Pérez-Gimeno G, Seral-Cortes M, Sabroso-Lasa S, Esteban LM, Widhalm K, Gottrand F, *et al.* Interplay of the Mediterranean diet and genetic hypertension risk on blood pressure in European adolescents: findings from the HELENA study. *Eur J Pediatr* 2024; 183:2101–2110.
73. Laitinen TT, Nuotio J, Niinikoski H, Juonala M, Rovio SP, Viikari JSA, *et al.* Attainment of targets of the 20-year infancy-onset dietary intervention and blood pressure across childhood and young adulthood: the Special Turku Coronary Risk Factor Intervention Project (STRIP). *Hypertension* 2020; 76:1572–1579.
74. Gidding SS. Improving children's diets needs a public health strategy. *Hypertension* 2020; 76:1418–1419.
75. Heo M, Rea CJ, Brady TM, Bundy DG, Melikam ES, Orringer K, *et al.* Racial and ethnic disparities in pediatric counseling on nutrition, lifestyle, and weight: a secondary analysis of the BP-CATCH randomized clinical trial. *JAMA Netw Open* 2025; 8:e2456238.
76. He FJ, MacGregor GA. Importance of salt in determining blood pressure in children: meta-analysis of controlled trials. *Hypertension* 2006; 48:861–869.
77. Leyvraz M, Chatelan A, da Costa BR, Taffé P, Paradis G, Bovet P, *et al.* Sodium intake and blood pressure in children and adolescents: a systematic review and meta-analysis of experimental and observational studies. *Int J Epidemiol* 2018; 47:1796–1810.
78. Ma Q, Li R, Wang L, Yin P, Wang Y, Yan C, *et al.* Temporal trend and attributable risk factors of stroke burden in China, 1990-2019: an analysis for the Global Burden of Disease Study 2019. *Lancet Public Health* 2021; 6:e897–e906.
79. Xun R, Gao Y, Zhen S, Mao T, Xia H, Zhang H, *et al.* Effects of behavioral interventions for salt reduction on blood pressure and urinary sodium excretion: a systematic review and meta-analysis of randomized controlled trials. *Glob Heart* 2023; 18:65.
80. He FJ, Marrero NM, MacGregor GA. Salt intake is related to soft drink consumption in children and adolescents: a link to obesity? *Hypertension* 2008; 51:629–634.
81. Zhou J, Sun W, Tang S, Jiang D, Tan B, Li S, *et al.* Effects of exercise interventions on blood pressure in children and adolescents with overweight or obesity: a systematic review and meta-analysis of randomized controlled trials. *J Adolesc Health* 2025; 76:361–369.
82. Eddolls WTB, McNarry MA, Stratton G, Winn CON, Mackintosh KA. High-intensity interval training interventions in children and adolescents: a systematic review. *Sports Med* 2017; 47:2363–2374.
83. Cai L, Wu Y, Wilson RF, Segal JB, Kim MT, Wang Y. Effect of childhood obesity prevention programs on blood pressure: a systematic review and meta-analysis. *Circulation* 2014; 129:1832–1839.
84. Beunza JJ, Martínez-González MA, Ebrahim S, Bes-Rastrollo M, Núñez J, Martínez JA, *et al.* Sedentary behaviors and the risk of incident hypertension: the SUN Cohort. *Am J Hypertens* 2007; 20:1156–1162.
85. Ketelhut S, Kircher E, Ketelhut SR, Wehlan E, Ketelhut K. Effectiveness of multiactivity, high-intensity interval training in school-aged children. *Int J Sports Med* 2020; 41:227–232.
86. Gregoski MJ, Barnes VA, Tingen MS, Harshfield GA, Treiber FA. Breathing awareness meditation and LifeSkills Training programs influence upon ambulatory blood pressure and sodium excretion among African American adolescents. *J Adolesc Health* 2011; 48: 59–64.
87. Sumner AL, Cartwright T, Ballieux H, Edginton T. School-based yoga and mindfulness interventions for young adolescents: a qualitative study in a disadvantaged area. *Br J Health Psychol* 2025; 30:e12793.
88. Crescentini C, Capurso V, Furlan S, Fabbro F. Mindfulness-oriented meditation for primary school children: effects on attention and psychological well being. *Front Psychol* 2016; 7:805.
89. Tsakona P, Kitsatis I, Apostolou T, Papadopoulou O, Hristara-Papadopoulou A. The effect of diaphragmatic breathing as a complementary therapeutic strategy in stress of children and teenagers 6-18 years old. *Children (Basel)* 2025; 12:59.
90. Bock JM, Vungarala S, Covassin N, Somers VK. Sleep duration and hypertension: epidemiological evidence and underlying mechanisms. *Am J Hypertens* 2022; 35:3–11.
91. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, *et al.* Consensus statement of the American Academy of Sleep Medicine on the Recommended Amount of Sleep for Healthy Children: methodology and discussion. *J Clin Sleep Med* 2016; 12:1549–1561.
92. Binka E, Brady TM. Real-world strategies to treat hypertension associated with pediatric obesity. *Curr Hypertens Rep* 2019; 21:18.

93. Kumar S, King EC, Christison AL, Kelly AS, Ariza AJ, Borzutzky C, *et al.* Health outcomes of youth in clinical pediatric weight management programs in POWER. *J Pediatr* 2019; 208:57–65. e4.
94. Reinehr T, Lass N, Toschke C, Rothermel J, Lanzinger S, Holl RW. Which amount of BMI-SDS reduction is necessary to improve cardiovascular risk factors in overweight children? *J Clin Endocrinol Metab* 2016; 101:3171–3179.
95. Resnicow K, McMaster F, Bocian A, Harris D, Zhou Y, Snetselaar L, *et al.* Motivational interviewing and dietary counseling for obesity in primary care: an RCT. *Pediatrics* 2015; 135:649–657.
96. Hsu MSH, Rouf A, Allman-Farinelli M. Effectiveness and behavioral mechanisms of social media interventions for positive nutrition behaviors in adolescents: a systematic review. *J Adolesc Health* 2018; 63:531–545.
97. Muth ND, Bolling C, Hannon T, Sharifi M. The role of the pediatrician in the promotion of healthy, active living. *Pediatrics* 2024; 153: e2023065480.
98. Hampl SE, Hassink SG, Skinner AC, Armstrong SC, Barlow SE, Bolling CF, *et al.* Clinical Practice Guideline for the Evaluation and Treatment of Children and Adolescents With Obesity. *Pediatrics* 2023; 151:e2022060640.
99. Wirix AJ, Verheul J, Groothoff JW, Nauta J, Chinapaw MJ, Kist-van Holthe JE. Screening, diagnosis and treatment of hypertension in obese children: an international policy comparison. *J Nephrol* 2017; 30:119–125.
100. Banati P, Vedechkina M, Krishna A, Santos RJ, Banerjee A, Baltag V. WHO's global roadmap to tackle adolescent hypertension. *Lancet Child Adolesc Health* 2025; 9:367–368.
101. Dionne JM, Harris KC, Benoit G, Feber J, Poirier L, Cloutier L, *et al.* Hypertension Canada's 2017 Guidelines for the Diagnosis, Assessment, Prevention, and Treatment of Pediatric Hypertension. *Can J Cardiol* 2017; 33:577–585.
102. Simonetti GD, Rizzi M, Donadini R, Bianchetti MG. Effects of antihypertensive drugs on blood pressure and proteinuria in childhood. *J Hypertens* 2007; 25:2370–2376.
103. Welch WP, Yang W, Taylor-Zapata P, Flynn JT. Antihypertensive drug use by children: are the drugs labeled and indicated? *J Clin Hypertens (Greenwich)* 2012; 14:388–395.
104. Moreno M, Thompson L. What is adolescent and young adult medicine? *JAMA Pediatr* 2020; 174:512.
105. White PH, Cooley WC. Transitions Clinical Report Authoring Group; American Academy of Pediatrics; American Academy of Family Physicians; American College of Physicians. Supporting the health-care transition from adolescence to adulthood in the medical home. *Pediatrics* 2018; 142:e20182587 Pediatrics, 2019. 143(2).
106. Lee H, Yano Y, Cho SMJ, Heo JE, Kim DW, Park S, *et al.* Adherence to antihypertensive medication and incident cardiovascular events in young adults with hypertension. *Hypertension* 2021; 77:1341–1349.
107. World Health Organization (WHO), Adolescent health. [internet] https://www.who.int/southeastasia/health-topics/adolescent-health. [Accessed 18 July 2025].
108. Lugasi T, Achille M, Stevenson M. Patients′ perspective on factors that facilitate transition from child-centered to adult-centered healthcare: a theory integrated metasummary of quantitative and qualitative studies. *J Adolesc Health* 2011; 48:429–440.
109. Tong A, Henning P, Wong G, McTaggart S, Mackie F, Carroll RP, *et al.* Experiences and perspectives of adolescents and young adults with advanced CKD. *Am J Kidney Dis* 2013; 61:375–384.
110. Tong A, Gow K, Wong G, Henning P, Carroll R. Patient perspectives of a young adult renal clinic: a mixed-methods evaluation. *Nephrology (Carlton)* 2015; 20:352–359.
111. Miller C. Using technology to bridge the transition from pediatric to adult healthcare. *J Am Assoc Nurse Pract* 2022; 34:850–858.
112. Samarasinghe SC, Al Na′abi R, Cheng HL, Yeung J, Steinbeck KS. A mobile phone app to support self-management and transition to adult health services in young people with a chronic illness: single-arm pilot intervention study. *JMIR Pediatr Parent* 2025; 8:e67061.