Cincinnati Children's Hospital Medical Center Best Evidence Statement (BESt)

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Blood Pressure Measurement in Children

Clinical Question

P (population/problem)	In pediatric patients
I (intervention)	what is the best method of blood pressure measurement
C (comparison)	
O (outcome)	to identify elevated blood pressure?

Target Population

Pediatric patients (0 to 18 years)

Recommendation(s) (See Table of Recommendation Strengths following references)

Patients

1. It is recommended that children over the age of 3 years have their blood pressure measured at least once a year as part of routine preventive health screening *(AAP Committee on Practice and Ambulatory Medicine and Bright Futures Steering Committee 2007 [5], Local Consensus [5])*.
   Note: Data from the 2006 National Ambulatory Medical Care Summary indicates that blood pressure was recorded at 25.8% (SE 1.6) of visits by children (0-17 years of age) *(Cherry 2008 [4a])*.

2. It is recommended that all children with any chronic medical condition(s) and/or being treated with medications known to raise blood pressure have their blood pressure measured at least once during every health care encounter *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Local Consensus [5])*.

Method

3. It is recommended that auscultation with mercury or aneroid sphygmomanometer be used for diagnostic evaluation of blood pressure elevation *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Local Consensus [5])*.
   Note 1: Blood pressure measurement with an oscillometric device may be acceptable for routine surveillance *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Jones 2003 [5], Local Consensus [5])*. An elevated blood pressure reading obtained with an oscillometric device should be repeated using the auscultatory method *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*.
   Note 2: Use of automated devices may be necessary for blood pressure measurement in newborns and young infants, in whom auscultation may be difficult *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Local Consensus [5])*.

4. It is recommended that the following procedure for blood pressure measurement be followed, regardless of the type of device used *(Pickering 2005 [5], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Chobanian 2003 [5b])*.
   a. Correct position: child is sitting, with legs uncrossed with cuff at heart level. Infants and small children may be lying down.
      Note: Blood pressure measurements may be elevated when the patient is lying down *(Eser 2007 [4b], Netea 2003 [4b])*. When patients are lying down, the arm used for blood pressure measurement is supported at the level of the right atrium to avoid falsely elevated blood pressure measurements *(Netea 2003 [4b])*.

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b. Rest period before measurement: at least 5 minutes of rest in sitting position before blood pressure measurement.
c. Correct size blood pressure cuff: use an appropriate cuff size based on arm circumference.
Note 1: The width of the cuff's inflatable bladder is at least 40% of arm circumference. The inflatable bladder length should cover 80-100% of the circumference of the arm *(Pickering 2005 [5], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*.
Note 2: Refer to manufacturer's marks on the cuff to determine the correct cuff size or measure the arm circumference at the midpoint between the olecranon and the acromion.
Note 3: If a cuff is too small, the next largest cuff should be used, even if it appears large.
d. Average of two measurements: to best characterize blood pressure values, obtain an average of 2 or more values. If blood pressure is elevated, wait at least 30 seconds and repeat the measurement. Reported blood pressure for the visit is the average of the two sets of values.

Confirmation of Elevated Blood Pressure

5. It is recommended that the following guidelines be used to diagnose elevated blood pressure, based on the current gender-, age-, and height-appropriate blood pressure tables *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*.
   a. Systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) (i.e., average of two measurements as per 4d. above) less than the 90th percentile is normal.
   b. Systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) (i.e., average of two measurements as per 4d. above) between the 90th and 95th percentile or BP equal to or exceeding 120/80 at any age is prehypertension (see Table below) *(Local Consensus [5])*
   c. Systolic blood pressure (SBP) and/or diastolic blood pressure (DBP) (i.e., average of two measurements as per 4d. above) greater than 95th percentile on ≥3 occasions is hypertension.

6. It is recommended that elevated blood pressure measurements be confirmed on repeated visits before characterizing a child as having prehypertension or hypertension (See Table below) *(Pickering 2005 [5], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Local Consensus [5])*.
   Note 1: Incorrect technique may result in inaccurate blood pressure measurements *(Eser 2007 [4b], Prineas 2007 [4b], Sala 2005 [4b], Mourad 2003 [4b], Netea 2003 [4b], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Jones 2003 [5], Local Consensus [5])*– See Blood Pressure Assessment Algorithm on page 7.
   Note 2: Blood pressure at high levels tends to fall on subsequent measurements as the result of (1) an accommodation effect (i.e. reduction of anxiety by the patient from one visit to the next), and (2) regression to the mean.*(Chiolero 2007 [4a], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*.
   Note 3: Recommended frequency of measurement varies with blood pressure level (see Table below).

Table: Classification of Hypertension in Children and Adults with Measurement Frequency

	SBP* or DBP** Percentile	Frequency of BP Measurement
Normal	< 90th percentile	Recheck at next scheduled physical examination.
Prehypertension	90th to < 95th percentiles **or** ≥ 120/80 at any age	Recheck in 6 months.
Stage 1 hypertension	> 95th and < 99th percentile plus 5 mmHg	Recheck in 1-2 weeks or sooner if patient is symptomatic. If persistently elevated on 2 additional occasions, evaluate or refer to hypertension specialist within 1 month
Stage 2 hypertension	> 99th percentile plus 5 mmHg	Evaluate or refer to pediatric hypertension specialist (e.g pediatric nephrology or pediatric cardiology) within 1 week or immediately if symptomatic

*Systolic blood pressure **Diastolic blood pressure
Source: *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*

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7. It is recommended that children and adolescents be referred according to their blood pressure values (See Appendix):
   a. Children and adolescents whose blood pressure is ≥ 90th percentile but < 99th percentile plus 5 mmHg can be referred to primary care provider for confirmation or consider referring to a pediatric hypertension specialist (e.g., pediatric nephrology or pediatric cardiology) *(Local Consensus [5])*.
   b. If a patient's blood pressure is > 99th percentile plus 5 mmHg, the patient should be referred to a pediatric hypertension specialist (i.e., pediatric nephrology or pediatric cardiology) for prompt evaluation and treatment *(Local Consensus [5])*.

Discussion/summary of evidence

In 2004, the Fourth Report on the Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])* (hereafter referred to as the Fourth Report) was published. This report was an update of an earlier national consensus reports *(National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents 1996 [5], Second Task Force on Blood Pressure Control in Children 1987 [5], Blumenthal 1977 [5])*, based on peer-reviewed scientific literature published in English since 1997. In the Fourth Report *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*, revisions pertinent to blood pressure measurement included revised blood pressure tables and the identification of blood pressure values that indicate prehypertension, which are consistent with the Joint National Committee on the Prevention, Detection, Evaluation and Treatment of High Blood Pressure (JNC 7) *(Chobanian 2003 [5b])*.

A search of the literature since 2003 was performed (see Search Strategy below). No evidence to invalidate the Fourth Report *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])* was found, although several studies related to blood pressure measurement were identified.

The Fourth Report *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])* recommends the auscultatory method of blood pressure measurement as the standard for diagnosis of elevated blood pressure, in part because the current NHBLI blood pressure tables are based on ausculatory measurements. Blood pressure values obtained with an oscillometric device are not interchangeable with values obtained by auscultation or values obtained with different oscillometric devices *(Pickering 2005 [5], National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5], Butani 2003 [5])*.Since the report was published, several authors have published nomograms for oscillometric blood pressure measurements for different ages *(Kent 2007 [4a], Park 2005 [4b])* and racial/ethnic groups *(Sung 2008 [4a])*.

The Fourth Report *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])* recommends that a consistent method be used to measure blood pressure to ensure accurate, reproducible and comparable blood pressure values. After comparing four different methods of blood pressure measurement, Houweling et al *(2006 [4a])* demonstrated that different measurement methods produce different blood pressure values, reinforcing the need for use of a consistent method of blood pressure measurement in order to compare blood pressure values over time. Several investigators demonstrated that body position, such as whether the patient is lying down, whether the arm is supported or unsupported, and whether the antecubital space is on the same level of the right atrium, influences blood pressure values *(Eser 2007 [4b], Sala 2005 [4b], Mourad 2003 [4b], Netea 2003 [4b])*. Blood pressure cuff size should be based on measured mid-arm circumference, measured at the mid-point between the olecranon and the acromion. In very small neonates, oscillometric blood pressure measurements may be too high, due to limitations in available cuff sizes for very small arm circumferences *(Dannevig 2005 [4b])*. Prineas *(2007 [4b])* examined trends in mid-arm-circumference and the availability of appropriate blood pressure cuff sizes, concluding that an increasing number of falsely high blood pressure measurements were likely due to lack of adequate sizes of pediatric blood pressure cuffs even though mid-arm circumference measurements in children are increasing.

Podoll et al. *(2007 [4b])* compared the blood pressure measurements obtained by staff using standard practice at the "vital signs station" in a pediatric hypertension clinic and the blood pressure measurements obtained in the examination room by trained personnel carefully following the Fourth Report method for blood pressure

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measurement. Blood pressure measurements taken at the vital signs stations were higher than those taken in the examination room: the mean difference between the two readings was > 13 mm Hg for SBP and 9 mm Hg for DBP. With this difference, some normotensive patients would be misdiagnosed as having prehypertension or hypertension. The results of this study suggest that if vital signs station blood pressure measurements are elevated, children with elevated initial measurements must be checked in the examination room before a making a diagnosis.

Health Benefits, Side Effects and Risks

The Fourth Report emphasizes importance of early recognition of both prehypertension and hypertension in children and adolescents, due to present and future health risks, including target-organ abnormalities and the risk of cardiovascular disease *(National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents 2004 [5])*. Several reports published since the Fourth Report have confirmed the presence of cardiovascular risk factors in youths with elevated blood pressure *(Zhu 2007 [3a], Juonala 2006 [3a], Lane 2004 [5])*and obesity *(Sorof 2004 [4b])*.

References/citations (Evidence grade in *[ ]; see Table of Evidence Levels following references*)

Note: When using the electronic version of this document, ☜ indicates a hyperlink to the PubMed abstract. A hyperlink following this symbol goes to the article PDF when the user is within the CCHMC network.

1. **AAP Committee on Practice and Ambulatory Medicine and Bright Futures Steering Committee:** Recommendations for Preventive Pediatric Health Care. *Pediatrics*, 120(6): 1376, 2007, *[5]* ☜.

2. **Blumenthal, S. et al.:** Report of the task force on blood pressure control in children. *Pediatrics*, 59(5 2 suppl): I-II, 1977, *[5]* ☜.

3. **Butani, L.; Morgenstern, B. Z.; Butani, L.; and Morgenstern, B. Z.:** Are pitfalls of oscillometric blood pressure measurements preventable in children? *Pediatric Nephrology*, 18(4): 313-8, 2003, *[5]* ☜.

4. **Cherry, D., Hing, E, Woodwell, DA, Rechtsteiner, EA:** National Ambulatory Medical Care Survey: 2006 Summary. *National Health Statistics Reports*, 3(1): 1-39, 2008, *[4a]* ☜.

5. **Chiolero, A.; Cachat, F.; Burnier, M.; Paccaud, F.; and Bovet, P.:** Prevalence of hypertension in schoolchildren based on repeated measurements and association with overweight. *Journal of Hypertension*, 25(11): 2209-17, 2007, *[4a]* ☜.

6. **Chobanian, A. V. et al.:** The Seventh Report of the Joint National Committee on Prevention, Detection, Evaluation, and Treatment of High Blood Pressure: the JNC 7 report. *JAMA*, 289(19): 2560-72, 2003, *[5b]* ☜.

7. **Dannevig, I.; Dale, H. C.; Liestol, K.; and Lindemann, R.:** Blood pressure in the neonate: three non-invasive oscillometric pressure monitors compared with invasively measured blood pressure. *Acta Paediatr*, 94(2): 191-6, 2005, *[4b]* ☜.

8. **Eser, I.; Khorshid, L.; Gunes, U. Y.; and Demir, Y.:** The effect of different body positions on blood pressure. *J Clin Nurs*, 16(1): 137-40, 2007, *[4b]* ☜.

9. **Houweling, S. T.; Kleefstra, N.; Lutgers, H. L.; Groenier, K. H.; Meyboom-de Jong, B.; and Bilo, H. J.:** Pitfalls in blood pressure measurement in daily practice. *Fam Pract*, 23(1): 20-7, 2006, *[4a]* ☜.

10. **Jones, D. W.; Appel, L. J.; Sheps, S. G.; Roccella, E. J.; and Lenfant, C.:** Measuring blood pressure accurately: new and persistent challenges. *JAMA*, 289(8): 1027-30, 2003, *[5]* ☜.

11. **Juonala, M.; Viikari, J. S.; Ronnemaa, T.; Helenius, H.; Taittonen, L.; and Raitakari, O. T.:** Elevated blood pressure in adolescent boys predicts endothelial dysfunction: the cardiovascular risk in young Finns study. *Hypertension*, 48(3): 424-30, 2006, *[3a]* ☜.

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12. **Kent, A. L.; Kecskes, Z.; Shadbolt, B.; Falk, M. C.; Kent, A. L.; Kecskes, Z.; Shadbolt, B.; and Falk, M. C.:** Blood pressure in the first year of life in healthy infants born at term. *Pediatric Nephrology*, 22(10): 1743-9, 2007, *[4a]* _____ ☜ _____.

13. **Lane, D. A., and Gill, P.:** Ethnicity and tracking blood pressure in children. *Journal of Human Hypertension*, 18(4): 223-8, 2004, *[5]* _____ ☜ _____.

14. **Local Consensus:** During BESt development time frame. *[5]*.

15. **Mourad, A.; Carney, S.; Gillies, A.; Jones, B.; Nanra, R.; and Trevillian, P.:** Arm position and blood pressure: a risk factor for hypertension? *Journal of Human Hypertension*, 17(6): 389-95, 2003, *[4b]* _____ ☜ _____.

16. **National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents:** The fourth report on the diagnosis, evaluation, and treatment of high blood pressure in children and adolescents.[see comment]. *Pediatrics*, 114(2 Suppl 4th Report): 555-76, 2004, *[5]* _____ ☜ _____.

17. **National High Blood Pressure Education Program Working Group on Hypertension Control in Children and Adolescents:** Update on the 1987 Task Force Report on High Blood Pressure in Children and Adolescents: a working group report from the National High Blood Pressure Education Program. . *Pediatrics*, 98(4 Pt 1): 649-58, 1996, *[5]* _____ ☜ _____.

18. **Netea, R. T.; Lenders, J. W.; Smits, P.; and Thien, T.:** Both body and arm position significantly influence blood pressure measurement. *Journal of Human Hypertension*, 17(7): 459-62, 2003, *[4b]* _____ ☜ _____.

19. **Park, M. K.; Menard, S. W.; and Schoolfield, J.:** Oscillometric blood pressure standards for children. *Pediatric Cardiology*, 26(5): 601-7, 2005, *[4b]* _____ ☜ _____.

20. **Pickering, T. G. et al.:** Recommendations for blood pressure measurement in humans and experimental animals: Part 1: blood pressure measurement in humans: a statement for professionals from the Subcommittee of Professional and Public Education of the American Heart Association Council on High Blood Pressure Research.[see comment]. *Hypertension*, 45(1): 142-61, 2005, *[5]* _____ ☜ _____.

21. **Podoll, A.; Grenier, M.; Croix, B.; Feig, D. I.; Podoll, A.; Grenier, M.; Croix, B.; and Feig, D. I.:** Inaccuracy in pediatric outpatient blood pressure measurement. *Pediatrics*, 119(3): e538-43, 2007, *[4b]* _____ ☜ _____.

22. **Prineas, R. J. et al.:** US demographic trends in mid-arm circumference and recommended blood pressure cuffs for children and adolescents: data from the National Health and Nutrition Examination Survey 1988-2004. *Blood Pressure Monitoring*, 12(2): 75-80, 2007, *[4b]* _____ ☜ _____.

23. **Sala, C.; Santin, E.; Rescaldani, M.; Cuspidi, C.; and Magrini, F.:** What is the accuracy of clinic blood pressure measurement? *American Journal of Hypertension*, 18(2 Pt 1): 244-8, 2005, *[4b]* _____ ☜ _____.

24. **Second Task Force on Blood Pressure Control in Children:** Report of the Second Task Force on Blood Pressure Control in Children--1987. Task Force on Blood Pressure Control in Children. National Heart, Lung, and Blood Institute, Bethesda, Maryland. *Pediatrics*, 79(1): 1-25, 1987, *[5]* _____ ☜ _____.

25. **Sorof, J. M.; Turner, J.; Martin, D. S.; Garcia, K.; Garami, Z.; Alexandrov, A. V.; Wan, F.; and Portman, R. J.:** Cardiovascular risk factors and sequelae in hypertensive children identified by referral versus school-based screening. *Hypertension*, 43(2): 214-8, 2004, *[4b]* _____ ☜ _____.

26. **Sung, R. Y. et al.:** Oscillometrically measured blood pressure in Hong Kong Chinese children and associations with anthropometric parameters. *Journal of Hypertension*, 26(4): 678-84, 2008, *[4a]* _____ ☜ _____.

27. **Zhu, H. et al.:** Cardiovascular characteristics in American youth with prehypertension. *American Journal of Hypertension*, 20(10): 1051-7, 2007, *[3a]* _____ ☜ _____.

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Note: Full tables of evidence grading system available in separate document:

- Table of Evidence Levels of Individual Studies by Domain, Study Design, & Quality (abbreviated table below)
- Grading a Body of Evidence to Answer a Clinical Question
- Judging the Strength of a Recommendation (abbreviated table below)

Table of Evidence Levels (see note above)

Quality level	***Definition***
1a† or 1b†	Systematic review, meta-analysis, or meta-synthesis of multiple studies
2a or 2b	Best study design for domain
3a or 3b	Fair study design for domain
4a or 4b	Weak study design for domain
5	Other: General review, expert opinion, case report, consensus report, or guideline

†a = good quality study; b = lesser quality study

Table of Recommendation Strength (see note above)

Strength	***Definition***
"Strongly recommended"	There is consensus that benefits clearly outweigh risks and burdens (or visa-versa for negative recommendations).
"Recommended"	There is consensus that benefits are closely balanced with risks and burdens.
No recommendation made	There is lack of consensus to direct development of a recommendation.

Dimensions: In determining the strength of a recommendation, the development group makes a considered judgment in a consensus process that incorporates critically appraised evidence, clinical experience, and other dimensions as listed below.

1. Grade of the Body of Evidence (see note above)
2. Safety / Harm
3. Health benefit to patient *(direct benefit)*
4. Burden to patient of adherence to recommendation *(cost, hassle, discomfort, pain, motivation, ability to adhere, time)*
5. Cost-effectiveness to healthcare system *(balance of cost / savings of resources, staff time, and supplies based on published studies or onsite analysis)*
6. Directness *(the extent to which the body of evidence directly answers the clinical question [population/problem, intervention, comparison, outcome])*
7. Impact on morbidity/mortality or quality of life

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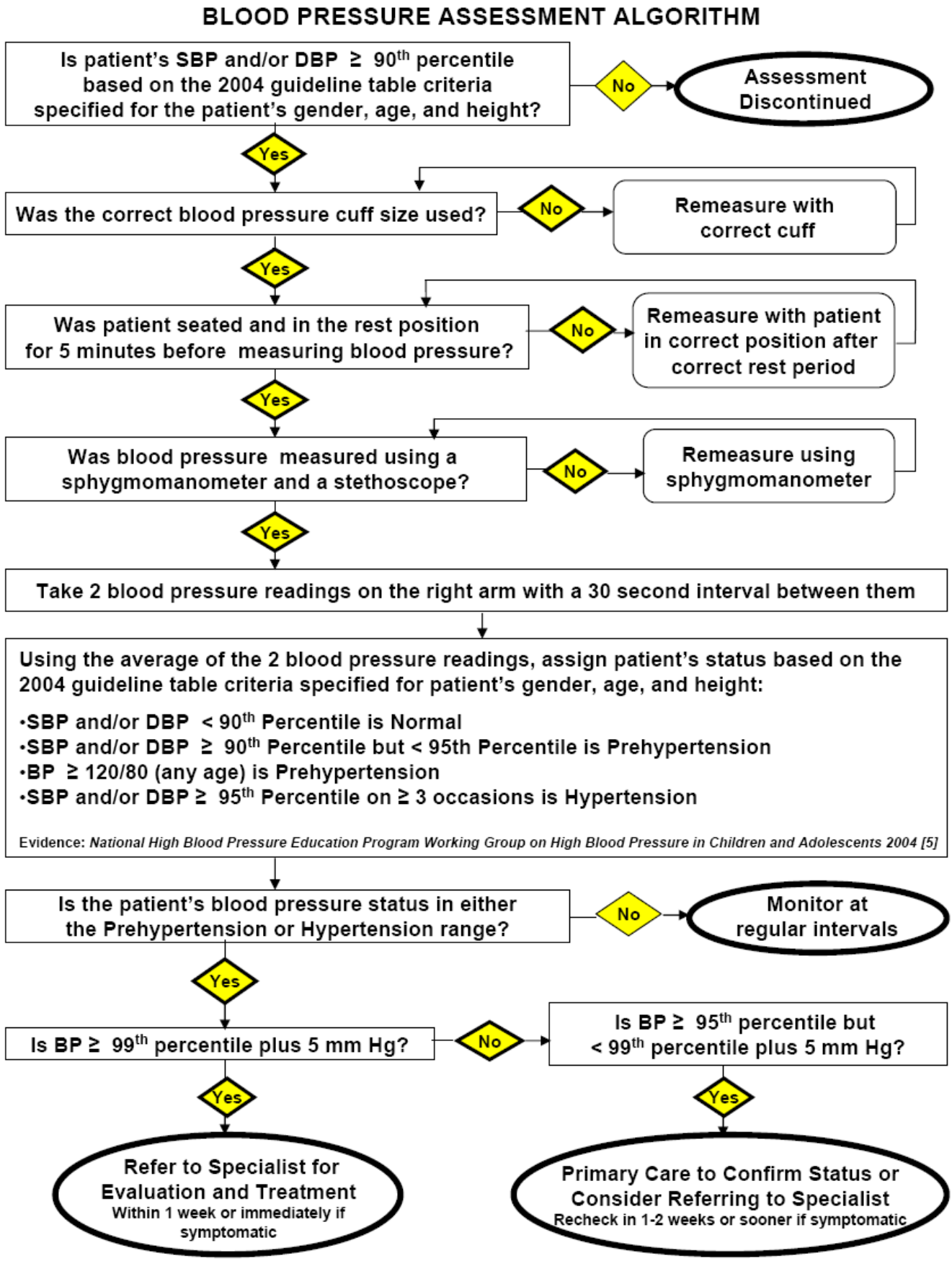
Appendix



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Supporting information

Group/team members

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Search strategy

1. **Original Search**
   OVID Databases
   Medline, CINAHL and the Cochrane Database for Systematic Reviews (CDSR)

   OVID Filters

Publication Date	2003 to present
Limits	Humans and English Language "All child (0 to 18 years)"
Journal Filter	General interest medical journals: British Medical Journal, JAMA, Lancet, New England Journal of Medicine General interest pediatric journals: Archives of Diseases in Childhood Archives of Diseases in Childhood Fetal & Neonatal Edition, Archives of Pediatric and Adolescent Medicine, Journal of Pediatrics, Pediatrics Topic-specific specialty journals: American Heart Journal, American Journal of Cardiology, American Journal of Hypertension, Blood Pressure Monitoring, Hypertension, Journal of Human Hypertension, Journal of Hypertension, Pediatric Nephrology

   Search Terms and MeSH Terms

Patients/Population	Pediatric patients, pediatrics Ambulatory patients/outpatients
Intervention/Exposure	Blood Pressure/ph [Physiology] Blood Pressure Determination/ct [Contraindications]] Blood Pressure Determination/is [Instrumentation] Blood Pressure Determination/mt [Methods] Blood Pressure Determination/st [Standards] Blood Pressure Determination/sn [Statistics & Numerical Data] Diagnostic Errors/in [Instrumentation]] Diagnostic Errors/sn [Statistics & Numerical Data] Predictive Value of Tests – additional limits Diagnosis/specificity, Diagnosis/sensitivity Casual blood pressure measurements.mp
Outcomes	Accurate blood pressure measurement

2. **Additional articles** identified from reference lists and clinicians.

Known conflicts of interest

Elaine Urbina MD is a member of the National High Blood Pressure Education Program Working Group on High Blood Pressure in Children and Adolescents.

Applicability issues

Outcomes that are planned to be measured include:
1. Percent of patients having blood pressure evaluated at current visit
2. Percent of patients having blood pressure measurements documented in structured data fields (completeness)
3. Proportion of population accurately diagnosed as hypertensive.
4. Proportion of population accurately diagnosed as pre-hypertensive.
5. Percent of at-risk patients whose elevated blood pressure is confirmed by using the gold standard measurement process (all or none composite)

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Complete operational definitions are on file.

Copies of this Best Evidence Statement (BESt) are available online and may be distributed by any organization for the global purpose of improving child health outcomes. Website address: http://www.cincinnatichildrens.org/svc/alpha/h/health-policy/ev-based/default.htm
Examples of approved uses of the BESt include the following:

- copies may be provided to anyone involved in the organization's process for developing and implementing evidence based care;
- hyperlinks to the CCHMC website may be placed on the organization's website;
- the BESt may be adopted or adapted for use within the organization, provided that CCHMC receives appropriate attribution on all written or electronic documents; and
- copies may be provided to patients and the clinicians who manage their care.

Notification of CCHMC at HPCEInfo@cchmc.org for any BESt adopted, adapted, implemented or hyperlinked by the organization is appreciated.

*Additionally, for more information about CCHMC Best Evidence Statements and the development process, contact the Health Policy & Clinical Effectiveness office at: 513-636-2501 or **HPCEInfo@chmcc.org**.*

Note

This Best Evidence Statement addresses only key points of care for the target population; it is not intended to be a comprehensive practice guideline. These recommendations result from review of literature and practices current at the time of their formulation. This Best Evidence Statement does not preclude using care modalities proven efficacious in studies published subsequent to the current revision of this document. This document is not intended to impose standards of care preventing selective variances from the recommendations to meet the specific and unique requirements of individual patients. Adherence to this Statement is voluntary. The clinician in light of the individual circumstances presented by the patient must make the ultimate judgment regarding the priority of any specific procedure.

Reviewed by: Clinical Effectiveness

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