What Is ‘Normal?’ Evaluating Vital Signs

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Vital signs (VS) are indicators of physiological functioning and include temperature, respiratory rate, heart rate (pulse), and blood pressure (BP). Health care professionals measure VS to assess, monitor, evaluate, and document an individual's physiological status or change in condition (Royal College of Nursing, 2011). Depending on the individual's condition, VS are monitored and recorded routinely by policy, tradition, or expert opinion, whether needed or not (Evans, Hodgkinson, & Berry, 2001; Zeitz & McCutcheon, 2006). Five years ago, pediatric nurse leaders and evidence-based practice (EBP) experts from children's hospitals across the country voiced concerns about the frequency of VS at a National Summit for Pediatric and Adolescent Evidence-Based Practice (Melyn, et al., 2007). This summit resulted in our team formulating a clinical question, searching for the evidence, critically appraising the evidence, and formulating conclusions on normal parameters.

Before the question on the frequency of VS could be addressed, two fundamental questions needed exploration, and thus, became the focus of our work. The questions are:

- Among pediatric patient ages 1 through 5 years, what are “normal” VS parameters?
- Among pediatric patient ages 1 through 5 years, what is a significant change in VS?

The purpose of this systematic review was to determine the best evidence for normative parameters for VS in healthy children 1 to 5 years of age and what constituted a clinically significant change in VS in hospitalized, but otherwise healthy, children.

**Methodology**

Literature searches using keywords “vital signs,” “blood pressure,” “heart rate,” “respiratory rate,” “normal,” “normative,” “early warning,” “deterioration,” “pediatric,” and “children” were run using the EBSCO, CINAHL, PubMed, and Scopus databases. Additionally, authors performed manual searches of references, guidelines, and textbooks. Articles and texts were excluded if they did not address children 1 to 5 years of age, or if they addressed a specific disease or illness process, such as cardiovascular disease or asthma. Eight textbooks and four review articles containing pediatric normative VS parameters were reviewed. The search revealed nine articles reporting research findings on one or more parameters. In addition, six articles about pediatric early warning parameters were also reviewed.

Evidence was then rated based on the system proposed by Melnyk and Fineout-Overholt (2011). In this rating system, Level I is the highest ranked and includes a systematic review or meta-analysis. Level II, consists of randomized controlled trials, while Level III lacks the randomization of the previous level. Case-control and cohort studies comprise Level IV, and a systematic review from descriptive studies is rated as Level V. Level VI is based on evidence from one descriptive or qualitative study. The lowest level of evidence is Level VII; which is classified as expert opinion from individuals or committees.

**Review of the Literature**

**Textbooks**

Nursing and medical textbooks often provide tables with normative data for VS; however, the tables were not consistent across texts. Although parameter ranges overlapped and were similar, some differences were notable.
For instance, for children 3 years of age, Bowden and Greenberg (2008) listed a normal heart rate (HR) range for children 3 to 4 years of age as 80 to 120 beats/minute, whereas Van Hare and Dubin (2001) grouped 3-year-olds with younger counterparts and listed 89 to 152 beats/minute to be the normative HR range. Several nursing textbooks reproduced a table from a medical textbook that displayed HR ranges dependent of age and wakefulness (Gillette et al., 1989). However, Gillette et al. (1989) cited only a 1981 study that found 65% of healthy 7- to 11-year-olds (N = 104) experience sinus pauses and heart rates below 45 to 55 beats/minute during the night hours when monitored over 24 hours (Southall, Johnston, Shinebourne, & Johnston, 1981). Other than this reference in Gillette et al. (1989), all other textbooks cited other textbooks for HR or respiratory rate normative data.

When presenting BP normative charts, textbooks refer to or reproduce the Fourth Report on High Blood Pressure in Children and Adolescents. The Fourth Report was developed from previously obtained datasets (National High Blood Pressure Education Program [NHBPEP] Working Group on High Blood Pressure in Children and Adolescents, 2004). This report presents the values for the 50th, 90th, 95th, and 99th percentiles for systolic BP (SBP) and diastolic BP (DBP) based on gender, age in years, and height percentiles, yielding a complex table of 1,904 values. The primary purpose of this report was “to provide recommendations for diagnosis, evaluation, and treatment of hypertension based on available evidence” (NHBPEP Working Group on High Blood Pressure in Children and Adolescents, 2004, p. 555). The Fourth Report defines pre-hypertension and hypertension based on the 90th and 95th percentile respectively (NHBPEP Working Group on High Blood Pressure in Children and Adolescents, 2004). Yet, many values for the 90th percentile fall above the 120/80 adult guidelines for hypertension (Kaelber & Pickett, 2009; Krishna, PrasannaKumar, Desai, & Thennarasu, 2006). Kaelber and Pickett (2009) have proposed a simplified table based on age and gender only, but again, the purpose is aimed at identifying children needing further attention regarding hypertension and do not provide minimum BP values. While these tables are based on a large dataset, the lack of control in the procedures of obtaining the data is a limitation.

One series of nursing textbooks (Hockenberry & Wilson, 2011; Wilson & Hockenberry, 2012) cite Park and Menard (1989) for normative oscillometric BP tables for infants through 5 years of age. Park and Menard (1989) showed that oscillometric BP readings were higher than those obtained by auscultation. Again, these textbook tables are indicated for diagnosis of hypertension versus full normative ranges for these ages.

Research Establishing Normative Parameters

After this review of a sample of nursing and medical textbooks, the authors concluded that there was a lack of consistency across textbooks in the presentation of normative values for VS. Additionally, the given normative values lacked reference to empirical data. Although BP charts cited research, the authors questioned using guidance on hypertension for purposes of determining normative values in the acute setting. The following is a review of recent research into determining normative values. Tables 1 to 3 give additional information on these studies. Not all studies produced normal ranges of values.

Studies on respiratory rates (RR) in children. The need for reference ranges prompted researchers in Italy to assess RR in healthy infants and young children (see Table 1) (Rusconi et al., 1994). Researchers measured RR by direct placement of stethoscope on the bare chest for 60 seconds. Rusconi et al. (1994) found evidence of significant difference in RR between awake and sleeping conditions. Further, RR measured by auscultation were significantly higher than by observation only in both awake and sleeping conditions (Rusconi et al., 1994). These findings are presented as smooth centile curves rather than as normal range of rates.

Wallis and associates completed two descriptive studies out of the United Kingdom and South Africa (Wallis, Healy, Undy, & Maconochie, 2005; Wallis & Maconochie, 2006). Both studies assessed fully clothed school children after 10 minutes of sitting. Researchers observed chest wall movements for 60-second observation. The authors maintained that this method of observation decreases child’s awareness as compared to a pneumogram or auscultation. Although researchers were explicit in counting partial breaths as full breaths, these articles refer to only one 60-second period being observed, and there is no reference to inter-rater reliability. The possibility of measurement error is a limitation to these studies, and therefore, do not give strong evidence of the normal distribution of respiratory rates.

In a meta-analysis of 69 studies reporting on respiratory rates and heart rates in children from birth to 18 years of age, Fleming et al. (2011) calculated RR and HR centiles. Methods of measuring RR were reported as primarily manual; however, manual was not defined. Smooth curve graphs are presented showing the decrease in RR as the child ages, but normal range of rates are not given.

Studies on heart rates (HR) in children. Studies aimed at determining normative HR in children have differed in the method of measurement and in the length of observation. Two studies by Wallis and associates also looked at defining the distribution of HR in healthy children (Wallis et al., 2005; Wallis & Maconochie, 2006). The procedures used a finger probe monitor for obtaining HR. The authors provided rationale using a finger probe, stating there was no evidence to suggest that HR would be altered by the presence of the probe (Wallis et al., 2005). However, the authors do not explain the reason for averaging the five-second intervals over a 60-second span. Both HR and RR normative ranges were derived from statistical transformations due to skewed distributions. These authors define normative HR and RR ranges by age based on the 2.5 and 97.5 percentile values from these samples (see Table 2).

Other studies have used 24-hour electrocardiogram (ECG) monitors to gather HR data. Massin, Bourguignon, and Gerard (2005) compared the HR and rhythms of healthy ambulatory children with hospitalized children. These authors provided data on minimum, maximum, and mean HR for groups; however, children 1 to 5 years of age were presented as one group. Another descriptive study of 616 children from birth to 20 years of age used Holter monitor recordings to establish age- and gender-based “lim-
its” (Salameh et al., 2008). Authors reported mean minimum HR and mean HR by age group; again children 1 to 5 years of age were presented as one group. No maximum HR was reported because activity was not controlled, and therefore, no “normative” ranges were given.

Other factors may influence HR in children. Fleming et al. (2011) identified several factors that influence HR in children. In addition to the setting and methods of measurement, their review also found the level of development of the country and year of the study to be factors in children’s HR.

Racial, ethnic, and gender disparities were also found. A descriptive study found African-American children 6 to 11 years of age had significantly higher HR ($p < 0.001$) during sleep than Caucasian and Hispanic children when body mass indices (BMIs) were equal (Archbold, Johnson, Goodwin, Rosen, & Quan, 2010). This study also found that girls had sleeping HRs near 3.5 beats/minute faster than boys.

**Studies on blood pressure in children.** As noted earlier, the most cited information on BP norms is from the Fourth Report. Current BP

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**Table 1. Research Studies on Normative Respiratory Rates in Children 1 to 5 Years of Age**

<table>
<thead>
<tr>
<th>Author, Date, Location</th>
<th>Design, Purpose</th>
<th>Sample Description</th>
<th>Measures</th>
<th>Findings</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rosconi et al. (1994); Italy</td>
<td>Descriptive subsample testing for stability across time, method of measure, and sleep status Purpose: To determine reference values for RR</td>
<td>$N = 618$; ages 15 months to 3 years old, no respiratory illness or severe disease or dehydration Settings: $n = 309$; daycare centers $n = 309$; inpatient and outpatient settings</td>
<td>Stethoscope placed on bare chest and measured for 60 seconds 50 children were measured twice 30 to 60 minutes apart with stethoscope 50 children assessed by auscultation and observation by 2 assessors simultaneously</td>
<td>Findings provided as smoothed centile curves for awake/calm and for asleep children by age  • No specific recommendations Repeatability over time: 95% RR by stethoscope significantly higher than by observation.  • 2.6 breaths/min when awake ($p = 0.015$)  • 1.8 breaths/min when asleep ($p &lt; 0.001$) Difference between awake/calm and asleep was significant ($p &lt; .001$) when controlling for gender, season, or setting</td>
<td>VI</td>
</tr>
<tr>
<td>Wallis et al. (2005); United Kingdom</td>
<td>Descriptive Purpose: Determine HR and RR reference values</td>
<td>$N = 1,109$ school children (4 to 16 years old) in quiet schoolroom setting; 31% response rate; $n = 49$; 4-year-olds $n = 69$; 5-year-olds</td>
<td>RR: 60 seconds of observation of clothed chest wall after 10 minutes of sitting quietly</td>
<td>Normal range defined by 2.5 and 97.5 percentiles</td>
<td>VI</td>
</tr>
<tr>
<td>Wallis &amp; Maconochie (2006); South Africa</td>
<td>Descriptive; replicated Wallis et al. (2005) Purpose: Compare sample to reference range established with Wallis et al. (2005) study</td>
<td>$N = 346$ children (5 to 16 years old) Setting: School serving socioeconomically disadvantaged groups</td>
<td>RR: 60 seconds of observation of clothed chest wall after 10 minutes of sitting quietly</td>
<td>Ranges given in box plot form Median RR (age 5) = 22 beats/minute</td>
<td>VI</td>
</tr>
<tr>
<td>Fleming et al. (2011); United Kingdom</td>
<td>Meta-analysis Purpose: Determine evidence for reference ranges</td>
<td>69 studies representing $N = 143,346$ healthy children</td>
<td>Data extraction included setting, method, awake/asleep, and age If multiple readings per group, metaanalysis used awake, baseline, least invasive measure</td>
<td>Centiles (1st, 10th, 25th, 50th, 75th, 90th, 99th) presented as curve Authors report differences found compared to accepted pediatric life support guidelines</td>
<td>V</td>
</tr>
</tbody>
</table>

**Notes:** HR = heart rate, RR = respiratory rate.
Table 2. Research Studies on Normative Heart Rate in Children 1 to 5 Years of Age

<table>
<thead>
<tr>
<th>Author, Date, Location</th>
<th>Design, Purpose</th>
<th>Sample Description</th>
<th>Measures</th>
<th>Findings</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Waliss et al. (2005); United Kingdom</td>
<td>Descriptive Purpose: Determine HR and RR reference values</td>
<td>( N = 1,109 ) school children (4 to 16 years old) in quiet schoolroom setting ( 31% ) response rate; ( n = 49; 4)-year-olds ( n = 69; 5)-year-olds</td>
<td>HR: 60 seconds with DatexS5 Lite monitor with finger probe Analysis: Mean of 5 second intervals</td>
<td></td>
<td>VI</td>
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<tr>
<td>Waliss &amp; Maconochie (2006); South Africa</td>
<td>Descriptive replicated Waliss et al. (2005) study Purpose: To compare this sample to reference range established with Waliss et al., 2005 study</td>
<td>( N = 346 ) children (5 to 16 years old) Setting: School serving socioeconomically disadvantaged groups</td>
<td>HR: 60 seconds with DatexS5 Lite monitor with finger probe Analysis: Mean of 5-second intervals</td>
<td>No significant difference between South African and UK sample (Waliss et al., 2005) HR ranges given in box plot form only Median HR (age 5) = 91 beats/minute</td>
<td>VI</td>
</tr>
<tr>
<td>Salameh et al. (2008); Germany</td>
<td>Descriptives Purpose: Evaluation of HR variability and establish age and gender HR limits for children 0 to 20 years old</td>
<td>( N = 616 ) outpatient children; all subject were ruled out for cardiac or thyroid disorders</td>
<td>Holter monitors with analysis on Mars 8000; RR intervals calculated for HR HR correlated to age using non-linear regression; ( R^2 = 0.66 ) to 0.78; ( p &lt; 0.0001 ) Gender differences found after age 10 Age greater than 1 to 5 years</td>
<td></td>
<td>VI</td>
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<tr>
<td>Massin et al. (2005); Belgium</td>
<td>Comparative study of ambulatory and hospitalized children Purpose: Determine differences in HR and rhythms</td>
<td>( N = 376 ) (ages birth to 16 years old) ( n = 264 ) healthy ambulatory children ( n = 112 ) hospitalized children Analysis grouped 1- to 5-year-olds in one group</td>
<td>Holter monitor MR45 Oxford with 2 channel tape recorders Analysis with Medilog Excel 2.0 Self-report diaries recording activities and times kept by child/parent</td>
<td>In the age group of 1 to 5 years old • No difference in HR between ambulatory (AMB) and hospitalized (HOSP) children • Supraventricular and ventricular contractions were common in both groups For 1 to 5 year olds</td>
<td>IV</td>
</tr>
<tr>
<td>Fleming et al. (2011); United Kingdom</td>
<td>Metaanalysis Purpose: to determine evidence-based RR and HR reference ranges</td>
<td>( N = 143,346 ) healthy children</td>
<td>Data extraction included setting, method, awake/asleep and age If multiple readings per group, metaanalysis used awake, baseline, least invasive measure</td>
<td>Centiles (1st, 10th, 25th, 50th, 75th, 90th, 99th) presented as curve Authors report differences found compared to accepted pediatric life support guidelines Significant predictors of HR include: • Setting (community higher) • Method (automated higher) • Country (developing higher) • Wakefulness (awake higher) • Year (older studies lower)</td>
<td>V</td>
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</tbody>
</table>

Notes: HR = heart rate, RR = respiratory rate.
### Table 3. Research Studies on Normative and High Blood Pressure in Children 1 to 5 Years of Age

<table>
<thead>
<tr>
<th>Author, Date, Location</th>
<th>Design, Purpose</th>
<th>Sample Description</th>
<th>Measures</th>
<th>Findings</th>
<th>Level of Evidence</th>
</tr>
</thead>
<tbody>
<tr>
<td>National High Blood Pressure</td>
<td>Descriptive, secondary analysis</td>
<td>11 studies from the United States N = 63,227, ages 1 to 17 years old</td>
<td>Blood pressure data from previous studies</td>
<td>Update BP distribution tables by gender, age, and height to include 50th, 90th, 95th, and 99th percentiles Yielding 56 values for each age (year) for SBP and DBP or a table of 1,904 values Normal BP: defined as the lesser of less than 90th percentile or less than 120/80</td>
<td>V</td>
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<tr>
<td>Education Program Working Group</td>
<td>Purpose: Update tables reporting distribution for the diagnosis of pre-hypertension and hypertension</td>
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<td>(2004); United States</td>
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<tr>
<td>Park, Menard, &amp; Schoolfield</td>
<td>Descriptive, exploratory Purpose: Generate normative BP tables for Dinemapp-obtained BP; explore relationship of BP to age, gender, weight, height</td>
<td>N = 7,208 schoolchildren, ages 5 to 17 years old</td>
<td>Dinemapp SBP readings 8 to 12 mmHg higher than auscultatory readings Dinemapp DBP readings 4 to 5 mmHg higher than K5 auscultatory reading</td>
<td>Blood pressure by gender and percentile for 5 year olds Weight is better predictor of BP than is height</td>
<td>VI</td>
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<tr>
<td>(2005); United States</td>
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<tr>
<td>Kaelber &amp; Pickett (2009); United</td>
<td>Descriptive; secondary analysis Purpose: Develop a simplified table for identifying high blood pressure</td>
<td>Data from The Fourth Report on Diagnosis, Evaluation and Treatment of High Blood Pressure in Children and Adolescents (2004)</td>
<td>Used lower limit of height (less than 5th percentile) and the abnormal (greater than 90th percentile) blood pressure for ages 3 to 17 years by gender Used recommended cutoff of SBP greater than or equal to 120 and DBP greater than or equal to 80</td>
<td>Blood pressures needing further evaluation for pre-hypertension Age is represented in years</td>
<td>VI</td>
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<tr>
<td>States</td>
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<tr>
<td>Haque &amp; Zaritsky (2007); United</td>
<td>Descriptive; secondary analysis Purpose: Extrapolate 5th percentile values for identifying hypotension</td>
<td>Data from 1987 Task Force reports on Hypertension. N &gt; 63,000; Children ages 1 to 17 years old.</td>
<td>Extrapolation from tables Assumed normal distribution of original data and that difference in pressure between 95th and 50th percentile was equal to difference between 5th and 50th percentile Data believed to be from auscultatory methods</td>
<td>Table for 5th percentile of SBP by height percentile and age and gender yielding 170 values SBP at 5th percentile ranges</td>
<td>VI</td>
</tr>
<tr>
<td>States</td>
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**Notes:** BP = blood pressure, DBP = diastolic blood pressure, SBP - systolic blood pressure.
nomograms are presented to account for age, gender, and height percentiles simultaneously (NHBPEP Working Group on High Blood Pressure in Children and Adolescents, 2004). Before 1993, BP tables were presented accounting for age and gender only, but prior research suggested physical maturity (vs. chronologic age) is the primary indicator of BP (Gillum, Prineas, & Horibe, 1982). In 1993, Rosner, Prineas, Loggie, and Daniels proposed that weight was not appropriate for accounting for maturity because the inclusion of obese children in the sample might lead to “normal” values that were unhealthy. Researchers in the United Kingdom found weight was a stronger predictor of normative BP than height when adjusting for age and gender in a sample of children and young adults ranging in age from 4 to 24 years (N = 22,901) (Jackson, Thalange, & Cole, 2007). They found that systolic blood pressure (SBP) and diastolic blood pressure (DBP) rose with age, but there was a marked increase at puberty with boys, which may have been linked with increase of weight at male puberty. Jackson et al. (2007) also redefined high BP at the 98th percentiles and high-normal between the 91st and 98th percentiles.

The issue of weight or BMI to predict higher BP, both systolic and diastolic, has been examined in the United States and China. Falkner and associates (2006) did a retrospective chart review of 18,618 children 2 to 19 years of age from pediatric primary care sites. BMI was a strong predictor of BP, even in children 2 to 5 years of age (n = 6331). Other predictors of BP were age, height, insurance type, and gender. In a sample of 208,513 young Chinese children approximately one month to 7 years of age, researchers compared obese with non-obese children (He, Ding, Fang, & Karlberg, 2000). Differences in SBP and DBP between groups became significant at 3 years of age for boys but not girls. Normative values for VS have been based on percentiles in the distribution of data from epidemiologic surveys. With evidence that weight and BMI factor into an increase in BP, Rosner, Cook, Portman, Daniels, and Falkner (2008) cautioned against adjusting normative values based on sampling that may include obese children.

Other factors in determining BP limits. Several studies gathering data on national normative BP values have been reported from countries as diverse as India and Saudi Arabia (Al Salloum, El Mouzan, Al Herbish, Al Omar, & Qurashi, 2009; Krishna et al., 2006). Krishna and colleagues (2006) eliminated both undernourished and obese children from the sample. Although there was no attempt to statistically compare values for Indian children to their American counterparts, Indian values for children 3 to 5 years of age were higher than those in the Fourth Report. The study from Saudi Arabia compared Saudi 90th percentile values to those of Turkish and American children and found a variance among the three samples (Al Salloum et al., 2009). A study in the United States compared rates of elevated BP between ethnic groups (White, Black, or Hispanic, by self-report) in U.S. children (Rosner et al., 2009). This secondary analysis of the dataset from the Fourth Report (n = 58,698) found that adjusting for BMI, Hispanic boys were more likely to have hypertension than were White boys (OR 1.21, p = 0.002), while Black boys were more likely to be prehypertensive than White boys (OR 1.32, p < 0.001). Girls did not have any differences between groups in hypertension after adjusting for BMI; however, Black girls were more likely to have prehypertension than White girls (OR 1.23, p < 0.001) and Hispanic girls were less likely to be prehypertensive compared to White girls (OR = 0.80, p = 0.01).

Studies have raised questions regarding diurnal changes and differences in method of obtaining BP. Lurbe and associates (1996) obtained 24 hours of ambulatory and conventional (oscillatory) BP reading on 228 normotensive children 6 to 16 years of age. The children were instructed to avoid vigorous physical activity while being monitored. Comparing average daytime BP between 0800 and 2000 to nighttime average measures taken between 2400 and 0600, Lurbe et al. (1996) found an average drop in SBP of 12.6 ± 6.7 in boys and 11.4 ± 5.7 in girls at night. DBP also dropped an average of 14.2 ± 5.9 (boys and girls combined). These significant nocturnal drops in BP were recorded in more than 80% of the children in the first phase of the study. However, the diurnal curve of BP parameters was not reproducible in a subsample of 31 children (Lurbe et al., 1996).

A difference between methods of BP measurement was also found significant. Several studies have pointed to BP measured by oscillatory were higher than those measured with auscultatory means (Lurbe et al., 1996; Midgley, Wardhaugh, Macfarlane, Magowan, & Kelnar, 2009; Park, Menard, & Schoolfield, 2005). Park et al. (2005) caution about false diagnoses of hypertension if the Fourth Report charts are used to evaluate BP’s obtained with an oscillatory method. These studies point to the lack of agreement on what are considered “normal” values for BP in children and the variations due to method of measurement. A weakness in many studies is the possible variance and measurement error due to protocol around the data collection and factors, such as cuff size, position of the child, and techniques of taking a measure.

Defining lower limits of BP. Haque and Zaritsky (2007) further explored data from the NHBPEP to develop tables for hypotension as defined by values that fall below the 5th percentile. These authors used the given values for the 50th and 95th percentiles, with the assumption of normal distribution, to calculate the values for 5th percentile based on gender, age, and height percentile. This work was not intended for use as normative data.

The literature on early warning tools was reviewed to determine what was known about significant change in VS parameters. Pediatric early warning tools have been developed in an effort to better predict deterioration and provide care that is timely. There were multiple tools identified in the literature (Duncan, Hutchison, & Parshuram, 2006; Edwards, Powell, Mason, & Oliver, 2009; Egdoll, Finlay, & Pedley, 2008; Haines, Perrott, & Weir, 2006; Monaghan, 2005; Parshuram, Hutchison, & Middaugh, 2009). These tools include varying parameters to assess deterioration of a child. The Brighton Paediatric Early Warning Score measures deterioration on three items of behavior, and cardiovascular and respiratory changes (Monaghan, 2005). For example, the respiratory item gives one point for more than 10 breaths per minute over the normal rate, two points for more than 20 above normal, and three points for five below the normal respiratory rate. Although HR and RR are included in the items for this tool, there is
little information on how these cutoff points were determined or what “normal” RR and HR were used. Subsequent studies (Akre et al., 2010; Tucker, Brewer, Baker, Demeritt, & Vossmeier, 2009) using this tool used the parameters listed in widely used pediatric nursing textbooks (T. Brewer, personal communication, May, 2009).

In contrast, the Paediatric Early Warning System Score (PEWS) and the Bristol Paediatric Early Warning Tool (PEW) have additional parameters, including oxygen therapy, demographics, medications, potassium levels, and seizure activities as indicators of deterioration (Duncan et al., 2006; Haines et al., 2006). These tools offer age-specific parameters for VS; however, only Duncan et al. (2006) report on the development of parameters, which was by modified Delphi to garner expert opinion. No research studies were cited for VS parameters in the early warning literature.

The objectives of the early warning research were directed at validating these tools rather than establishing parameters for specific VS. These studies offer some guidance on VS as indicators of deterioration. SBP was included in several tools, but only Parshuram et al. (2009) evaluated the SBP score for ability to discriminate between controls and ICU admissions. Although the SBP did not statistically predict ICU admission, the authors evaluated it to be clinically important and retained the SBP item in the tool (Parshuram et al., 2009). The Cardiff and Vale pediatric early warning system and the PEWS tools include a SBP item, but the reported analyses include only the ability of the tool as a whole to discriminate and do not address the items separately (Duncan et al., 2006; Edwards et al., 2009). The authors of the Brighton tool noted that while adult early warning tools use BP as a predictor, change in BP is considered a late sign of shock in children and was not included in the pediatric tool (Monaghan, 2005). HR and RR are included in all early warning tools reviewed. When these parameters were evaluated for ability to discriminate deterioration, Haines and associates (2006) found that bradycardia alone was not a predictor, and tachycardia was a useful discriminator only when tachycardia persisted following a fluid bolus of 2 to 20 ml/kg. However, tachypnea was a useful discriminator (Haines et al., 2006). Tume (2007) reviewed charts from children with unplanned admission to ICU or high dependency units (HDU) from the wards over a four-month period. This study using the Bristol tool found that tachypnea alone would have triggered the tool in 25% of those children admitted to ICU. Tume (2007) noted that respiratory distress was the main reason for admission in 55% cases of ICU admission and 54% HDU admissions.

A review of the early warning literature reveals there is lack of agreement on both the normative values for VS and what is considered a critical change in those parameters. No references to research studies were found in determining VS criteria within the early warning literature reviewed.

**Discussion**

The purpose of this review of the evidence was to look to the current literature to determine normative VS values, as well as define abnormal or significant changes in VS. To answer the clinical question, “Among pediatric patient ages 1 through 5 years, what are ‘normal’ VS parameters?” the authors reviewed a sampling of pediatric textbooks from the nursing and medical disciplines. The current normative HR and RR charts found in medical and nursing textbooks are inconsistent and are largely based on expert opinion (Level VII) and not based on research findings. Blood pressure normative data most frequently cited the Fourth Report (NHBPEP Working Group on High Blood Pressure in Children and Adolescents, 2004). This report was primarily designed for identifying hypertension in children and not to define normative ranges, although there has been some work on defining hypotension. Normative values for vital signs were inconsistent. How those values were reported was also inconsistent, with some values given as ranges and others as means or medians.

The inconsistency and paucity of evidence cited in the development of the VS charts prompted the authors to search for studies designed to establish normative values in children 1 to 5 years of age. The research literature has used descriptive design (Levels V and VI) (Melnik & Fineout-Overholt, 2011), which can be expected in developing normative charts. Normative charts have been based on a normal distribution of values, but there is inconsistency in the use of 5 and 95 percentiles (versus 2.5 and 90 or 97.5 percentiles) as the cutoff points for normal values. Methods of collecting VS data were inconsistent, despite literature on variations between different methods (Fleming et al., 2011; Park & Menard, 1989; Rusconi et al., 1994). One study measured RR by means of observation of the fully clothed child (Wallis et al., 2005), and a second study listened with a stethoscope to the bare chest wall (Rusconi et al., 1994). The inconsistency in the methods of measuring may introduce systematic error in synthesizing studies to determine normative values. Epidemiological studies of VS parameters have also been criticized for including children with unhealthy characteristics, for example, including hypertensive children in the sample that may increase the upper limits of normal BP (Rosner et al., 2008). A 2011 meta-analysis confirmed the finding of inconsistency across the literature (Fleming et al., 2011). This meta-analysis of the current evidence resulted in parameters that differed from those used in national and international life support guidelines on HR and RR in young children, further indicating more research is needed.

To answer the second clinical question, “Among pediatric patient ages 1 through 5 years, what is a significant clinical change in VS?” the literature on Early Warning Systems was reviewed. The normative VS values were inconsistent across the various systems. Additionally, not all studies sought to identify which items predicted deterioration of health status. When determining what change in VS was predictive of deterioration, tachypnea and respiratory distress were the primary predictors (Haines et al., 2006; Tume, 2007). Tachycardia was a predictor only if fluid status had been addressed (Haines et al., 2006). Blood pressure as a sign of shock was considered a late sign and was not included in one pediatric tool for that reason (Monaghan, 2005). Many early warning tools rely on behavioral changes and the nurses’ “worry” over the child as indicators of impending deterioration. Although there is good evidence of the need for screening for hypertension in children, support for the use of BP as a predictor of deterioration is limited due lack of norma-
tive data on the low end of BP and the lack of evidence in its usefulness as an early indicator of health status.

Implications for Clinical Practice and Future Research

The current normative VS parameters for children 1 to 5 years of age are not supported by strong and consistent evidence. Therefore, these authors recommend that in the acute care setting, comparing and contrasting a child’s own VS measurement changes throughout the shift or from previous shifts will assist the clinician in deciding the nursing intervention needed (Zeitz & McCutcheon, 2006). This nursing intervention is then based on the changes within the child’s parameters and on the current clinical evidence. The frequency of VS and interventions should be based on the child’s condition or fluctuation in their past values (Zeitz & McCutcheon, 2006). Additionally, an assessment of VS should be coupled with behavioral and physiologic indicators, such as decreased level of consciousness, capillary refill, and signs of respiratory distress (Duncan, 2007; Royal College of Nursing, 2011; Tucker et al., 2009; Tume, 2007).

Although frequency of VS was not examined in this study, given our findings, the value of checking VS every four hours is in question. Reliance on VS parameters alone for monitoring a child’s potential for deterioration may delay predicting decline and underplay the importance of other clinical indicators (Evans et al., 2001). Doing routine VS every four hours may place added burden on the child and family in loss of sleep. The cost in lost recuperative sleep to patients and families along with the costs of additional nursing time must be weighed against the benefit of routinely assessing VS, which may not be the best indication of deteriorating clinical status.

Future rigorous research aimed at defining normal and abnormal VS is needed. These studies should be based on defined age groups, race, gender, height, weight, activity level (awake/asleep), BMI, and health status. Methods of measurement are diverse in the studies reviewed (for example, the equipment used and position of the child). Studies must be explicit in the protocols used for gathering data, and consistency across studies is needed. Further studies that evaluate the clinical and behavioral parameters that signal a child’s health changes and deterioration are needed to guide early interventions and allay adverse outcomes. Other areas for research include the assessment of nursing time related to cost and improved outcomes and patient risk in terms of disrupted sleep.

Vital sign evaluation is often based on routine tradition. Evidence about normal values in young children is inconsistent and contradictory. Additionally, there is scarcity of high-quality, consistent research on normative VS values, the frequency of assessments, and behavioral and physiologic indicators that detect a decline in young hospitalized children. There are opportunities for further research in these areas. Clinicians need VS guidelines based on research to guide their clinical decision making and interventions.

References


What Is ‘Normal?’ Evaluating Vital Signs


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What Is ‘Normal?’ Evaluating Vital Signs

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Goal

The purpose of this article is to review the current literature and determine if EBP exists for normalcy of vital signs in the 1-5 year age groups.

Objectives
1. Determine the best evidence for normative parameters for VS in healthy children 1 to 5 years of age.

2. List two determinates of vital sign normalcy noted within the review of the literature.

3. Discuss the implications for clinical practice and future research.

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