

# Blood Pressure and Heart Rate Monitoring in Children

## Information Sheet for Primary Care Prescribers

### I. Blood Pressure

Manual blood pressure measurement using a sphygmomanometer is the gold standard in children, with direct arterial BP measuring in neonates. Blood pressure may be measured using an automated oscillometric device or a manual cuff and auscultation. Oscillometric devices may overestimate blood pressure so any high blood pressure measured this way should be checked manually.

There are a number of basic principles that should be adhered to regardless of method used to measure.

| Action                                                                                                                                                                                                                          | Rationale                                                                                                            |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------|
| Whenever possible the child should be rested for 3 minutes before each measurement.                                                                                                                                             | Activity elevates heart rate and blood pressure and will lead to inaccurate reading.                                 |
| Ensure the child is comfortable, with the limb used for measurement resting at heart level.                                                                                                                                     | If the child is uncomfortable it can increase heart rate and blood pressure, and will lead to an inaccurate reading. |
| The bladder in the cuff used should encircle 80-100% of the limb circumference (this is often indicated by a range guide on the cuff itself). The widest cuff available should be used. A selection of cuffs must be available. | A cuff that is too small will give a false high reading, and a cuff that is too large will give a false low.         |
| When possible the same limb, cuff and method of measurement should be used each time. Therefore it is important for this information to be clearly documented.                                                                  | For blood pressure readings to be comparable with each other the same method and equipment is needed.                |
| Always leave at least one minute between each reading.                                                                                                                                                                          | This enables the child to settle and become calm, to promote the accuracy of the reading.                            |

### Normal blood pressure readings for children

Children’s blood pressure increases with size. The most accurate way of measuring blood pressure is comparing readings based upon the child’s height, using the normal growth charts to determine the child’s percentile ([See appendix 1](#)). A child would be considered to be normotensive if their blood pressure is at the 90<sup>th</sup> percentile or less.

**Table 1: Definitions of BP Categories and Stages**

| For Children Aged 1–13 y                                                                                    | For Children Aged ≥13 y               |
|-------------------------------------------------------------------------------------------------------------|---------------------------------------|
| Normal BP: <90th percentile                                                                                 | Normal BP: <120/<80 mm Hg             |
| Elevated BP: ≥90th percentile to <95th percentile or 120/80 mm Hg to <95th percentile (whichever is lower)  | Elevated BP: 120/<80 to 129/<80 mm Hg |
| Stage 1 HTN: ≥95th percentile to <95th percentile + 12 mmHg, or 130/80 to 139/89 mm Hg (whichever is lower) | Stage 1 HTN: 130/80 to 139/89 mm Hg   |
| Stage 2 HTN: ≥95th percentile + 12 mmHg, or ≥140/90 mm Hg (whichever is lower)                              | Stage 2 HTN: ≥140/90 mm Hg            |

**Table 2: Management**

|                                                                                                                                                                       |                                                                                                                                                                                                                                                                                                                                                                                           |
|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Asymptomatic hypertension:</b> Average SBP $\geq 95^{\text{th}}$ to $95^{\text{th}} + 12\text{mmHg}$ , or for children aged 13 and over, 130/80 to 139/89 systolic | Investigate and lifestyle advice. Treat as per <a href="#">hypertension guideline in paediatric patients</a> . Recheck the BP in 1 to 2 weeks by <a href="#">auscultation (manual)</a> . If still at the <a href="#">stage 1 HTN level</a> , upper and lower extremity BP should be checked (right arm, left arm and 1 leg) and BP should be rechecked in 3 months. Refer as appropriate. |
| <b>Symptomatic hypertension and/or acute severe hypertension:</b> Average SBP of $\geq 95^{\text{th}}$ centile + 12mmHg or $\geq 140/90$ (whichever is lowest)        | Refer for hospital admission. Refer to paediatric hypertension specialist if blood pressure is consistently above the $95^{\text{th}}$ centile of age and height.                                                                                                                                                                                                                         |
| <b>Hypertensive crisis:</b> seizures, encephalopathy or cardiac failure                                                                                               | Require admission to an HDU or PICU setting                                                                                                                                                                                                                                                                                                                                               |

**Table 3: Blood pressure measurement using an automated monitor**

| Action                                                                                                                                 | Rationale                                                                                                               |
|----------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------|
| 1. Place the appropriate cuff on the child's limb, ensuring artery indicator is placed over the artery to be used for the measurement. | To ensure an accurate reading is obtained.                                                                              |
| The right arm should be used whenever possible. However, if this limb is injured or has a cannula in situ it should not be used.       |                                                                                                                         |
| 2. Switch on machine, and if possible set for 30mmHg above expected systolic pressure. This can be changed on many models.             | This will increase the accuracy of the reading, enabling the machine to detect the oscillations in pressure accurately. |
| 3. Press the machine to start, ensuring that the child is comfortable and the limb is supported.                                       |                                                                                                                         |
| 4. Remove cuff                                                                                                                         | To make the child comfortable                                                                                           |
| 5. Readings should be recorded accurately to 2mmHg, not rounded to the nearest value.                                                  | Rounding off to the nearest 5-10mmHg can result in an inaccurate reading affecting treatment decisions.                 |

## II. Heart Rate

Reference ranges for heart rate in children is summarised [here](#). Management of heart rate above 180 bpm in children can be found on [Supraventricular Tachycardia guideline](#).

### References:

1. Flynn JT, et al. Clinical Practice Guideline for Screening and Management of High Blood Pressure in Children and Adolescents. *Pediatrics*. 2017;140(3):e20171904
2. Great Ormond Street Hospital for Children. [Appendix 4 Normal Heart Rates](#). 2020. [Online]. Accessed on 12/08/2020.
3. Josep Brugada, et.al, Pharmacological and non-pharmacological therapy for arrhythmias in the pediatric population: EHRA and AEPC-Arrhythmia Working Group joint consensus statement, *EP Europace*, Volume 15, Issue 9, September 2013, Pages 1337–1382, <https://doi.org/10.1093/europace/eut082>
4. 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. *Pediatrics*. 2004;114(2 Suppl 4th Report):555-576.
5. Nottingham University Hospitals. Guideline for the assessment and management of Hypertension in Paediatric Patients. August 2020.
6. Nottingham University Hospitals. Guideline for the Management of Supraventricular Tachycardia in Children and Young People. June 2020.
7. Royal College of Nursing. Standards for Assessing, Measuring and Monitoring Vital Signs in Infants, Children and Young People. Royal College of Nursing, London. May 2020. [Online]. Accessed on 12/08/2020. [www.rcn.org.uk](http://www.rcn.org.uk)

**Appendix 1: Blood pressure centiles by gender, age and height centile**

| Table 1. BP Levels for Boys by Age and Height Percentile |                            |                                      |                  |                  |                  |                  |                  |                  |                                      |                  |                  |                  |                  |                  |                  |
|----------------------------------------------------------|----------------------------|--------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|--------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
| Age (y)                                                  | BP Percentile              | SBP (mm Hg)                          |                  |                  |                  |                  |                  |                  | DBP (mm Hg)                          |                  |                  |                  |                  |                  |                  |
|                                                          |                            | Height Percentile or Measured Height |                  |                  |                  |                  |                  |                  | Height Percentile or Measured Height |                  |                  |                  |                  |                  |                  |
|                                                          |                            | 5 <sup>th</sup>                      | 10 <sup>th</sup> | 25 <sup>th</sup> | 50 <sup>th</sup> | 75 <sup>th</sup> | 90 <sup>th</sup> | 95 <sup>th</sup> | 5 <sup>th</sup>                      | 10 <sup>th</sup> | 25 <sup>th</sup> | 50 <sup>th</sup> | 75 <sup>th</sup> | 90 <sup>th</sup> | 95 <sup>th</sup> |
| 1                                                        | 50 <sup>th</sup>           | 85                                   | 85               | 86               | 86               | 87               | 88               | 88               | 40                                   | 40               | 40               | 41               | 41               | 42               | 42               |
|                                                          | 90 <sup>th</sup>           | 98                                   | 99               | 99               | 100              | 100              | 101              | 101              | 52                                   | 52               | 53               | 53               | 54               | 54               | 54               |
|                                                          | 95 <sup>th</sup>           | 102                                  | 102              | 103              | 103              | 104              | 105              | 105              | 54                                   | 54               | 55               | 55               | 56               | 57               | 57               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 114                                  | 114              | 115              | 115              | 116              | 117              | 117              | 66                                   | 66               | 67               | 67               | 68               | 69               | 69               |
| 2                                                        | 50 <sup>th</sup>           | 87                                   | 87               | 88               | 89               | 89               | 90               | 91               | 43                                   | 43               | 44               | 44               | 45               | 46               | 46               |
|                                                          | 90 <sup>th</sup>           | 100                                  | 100              | 101              | 102              | 103              | 103              | 104              | 55                                   | 55               | 56               | 56               | 57               | 58               | 58               |
|                                                          | 95 <sup>th</sup>           | 104                                  | 105              | 105              | 106              | 107              | 107              | 108              | 57                                   | 58               | 58               | 59               | 60               | 61               | 61               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 116                                  | 117              | 117              | 118              | 119              | 119              | 120              | 69                                   | 70               | 70               | 71               | 72               | 73               | 73               |
| 3                                                        | 50 <sup>th</sup>           | 88                                   | 89               | 89               | 90               | 91               | 92               | 92               | 45                                   | 46               | 46               | 47               | 48               | 49               | 49               |
|                                                          | 90 <sup>th</sup>           | 101                                  | 102              | 102              | 103              | 104              | 105              | 105              | 58                                   | 58               | 59               | 59               | 60               | 61               | 61               |
|                                                          | 95 <sup>th</sup>           | 106                                  | 106              | 107              | 107              | 108              | 109              | 109              | 60                                   | 61               | 61               | 62               | 63               | 64               | 64               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 118                                  | 118              | 119              | 119              | 120              | 121              | 121              | 72                                   | 73               | 73               | 74               | 75               | 76               | 76               |
| 4                                                        | 50 <sup>th</sup>           | 90                                   | 90               | 91               | 92               | 93               | 94               | 94               | 48                                   | 49               | 49               | 50               | 51               | 52               | 52               |
|                                                          | 90 <sup>th</sup>           | 102                                  | 103              | 104              | 105              | 105              | 106              | 107              | 60                                   | 61               | 62               | 62               | 63               | 64               | 64               |
|                                                          | 95 <sup>th</sup>           | 107                                  | 107              | 108              | 108              | 109              | 110              | 110              | 63                                   | 64               | 65               | 66               | 67               | 67               | 68               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 119                                  | 119              | 120              | 120              | 121              | 122              | 122              | 75                                   | 76               | 77               | 78               | 79               | 79               | 80               |
| 5                                                        | 50 <sup>th</sup>           | 91                                   | 92               | 93               | 94               | 95               | 96               | 96               | 51                                   | 51               | 52               | 53               | 54               | 55               | 55               |
|                                                          | 90 <sup>th</sup>           | 103                                  | 104              | 105              | 106              | 107              | 108              | 108              | 63                                   | 64               | 65               | 65               | 66               | 67               | 67               |
|                                                          | 95 <sup>th</sup>           | 107                                  | 108              | 109              | 109              | 110              | 111              | 112              | 66                                   | 67               | 68               | 69               | 70               | 70               | 71               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 119                                  | 120              | 121              | 121              | 122              | 123              | 124              | 78                                   | 79               | 80               | 81               | 82               | 82               | 83               |
| 6                                                        | 50 <sup>th</sup>           | 93                                   | 93               | 94               | 95               | 96               | 97               | 98               | 54                                   | 54               | 55               | 56               | 57               | 57               | 58               |
|                                                          | 90 <sup>th</sup>           | 105                                  | 105              | 106              | 107              | 109              | 110              | 110              | 66                                   | 66               | 67               | 68               | 68               | 69               | 69               |
|                                                          | 95 <sup>th</sup>           | 108                                  | 109              | 110              | 111              | 112              | 113              | 114              | 69                                   | 70               | 70               | 71               | 72               | 72               | 73               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 120                                  | 121              | 122              | 123              | 124              | 125              | 126              | 81                                   | 82               | 82               | 83               | 84               | 84               | 85               |
| 7                                                        | 50 <sup>th</sup>           | 94                                   | 94               | 95               | 97               | 98               | 98               | 99               | 56                                   | 56               | 57               | 58               | 58               | 59               | 59               |
|                                                          | 90 <sup>th</sup>           | 106                                  | 107              | 108              | 109              | 110              | 111              | 111              | 68                                   | 68               | 69               | 70               | 70               | 71               | 71               |
|                                                          | 95 <sup>th</sup>           | 110                                  | 110              | 111              | 112              | 114              | 115              | 116              | 71                                   | 71               | 72               | 73               | 73               | 74               | 74               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 122                                  | 122              | 123              | 124              | 126              | 127              | 128              | 83                                   | 83               | 84               | 85               | 85               | 86               | 86               |
| 8                                                        | 50 <sup>th</sup>           | 95                                   | 96               | 97               | 98               | 99               | 99               | 100              | 57                                   | 57               | 58               | 59               | 59               | 60               | 60               |
|                                                          | 90 <sup>th</sup>           | 107                                  | 108              | 109              | 110              | 111              | 112              | 112              | 69                                   | 70               | 70               | 71               | 72               | 72               | 73               |
|                                                          | 95 <sup>th</sup>           | 111                                  | 112              | 112              | 114              | 115              | 116              | 117              | 72                                   | 73               | 73               | 74               | 75               | 75               | 75               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 123                                  | 124              | 124              | 126              | 127              | 128              | 129              | 84                                   | 85               | 85               | 86               | 87               | 87               | 87               |
| 9                                                        | 50 <sup>th</sup>           | 96                                   | 97               | 98               | 99               | 100              | 101              | 101              | 57                                   | 58               | 59               | 60               | 61               | 62               | 62               |
|                                                          | 90 <sup>th</sup>           | 107                                  | 108              | 109              | 110              | 112              | 113              | 114              | 70                                   | 71               | 72               | 73               | 74               | 74               | 74               |
|                                                          | 95 <sup>th</sup>           | 112                                  | 112              | 113              | 115              | 116              | 118              | 119              | 74                                   | 74               | 75               | 76               | 76               | 77               | 77               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 124                                  | 124              | 125              | 127              | 128              | 130              | 131              | 86                                   | 86               | 87               | 88               | 88               | 89               | 89               |
| 10                                                       | 50 <sup>th</sup>           | 97                                   | 98               | 99               | 100              | 101              | 102              | 103              | 59                                   | 60               | 61               | 62               | 63               | 63               | 64               |
|                                                          | 90 <sup>th</sup>           | 108                                  | 109              | 111              | 112              | 113              | 115              | 116              | 72                                   | 73               | 74               | 74               | 75               | 75               | 76               |
|                                                          | 95 <sup>th</sup>           | 112                                  | 113              | 114              | 116              | 118              | 120              | 121              | 76                                   | 76               | 77               | 77               | 78               | 78               | 78               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 124                                  | 125              | 126              | 128              | 130              | 132              | 133              | 88                                   | 88               | 89               | 89               | 90               | 90               | 90               |
| 11                                                       | 50 <sup>th</sup>           | 99                                   | 99               | 101              | 102              | 103              | 104              | 106              | 61                                   | 61               | 62               | 63               | 63               | 63               | 63               |
|                                                          | 90 <sup>th</sup>           | 110                                  | 111              | 112              | 114              | 116              | 117              | 118              | 74                                   | 74               | 75               | 75               | 75               | 76               | 76               |
|                                                          | 95 <sup>th</sup>           | 114                                  | 114              | 116              | 118              | 120              | 123              | 124              | 77                                   | 78               | 78               | 78               | 78               | 78               | 78               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 126                                  | 126              | 128              | 130              | 132              | 135              | 136              | 89                                   | 90               | 90               | 90               | 90               | 90               | 90               |
| 12                                                       | 50 <sup>th</sup>           | 101                                  | 101              | 102              | 104              | 106              | 108              | 109              | 61                                   | 62               | 62               | 62               | 62               | 63               | 63               |
|                                                          | 90 <sup>th</sup>           | 113                                  | 114              | 115              | 117              | 119              | 121              | 122              | 75                                   | 75               | 75               | 75               | 75               | 76               | 76               |
|                                                          | 95 <sup>th</sup>           | 116                                  | 117              | 118              | 121              | 124              | 126              | 128              | 78                                   | 78               | 78               | 78               | 78               | 79               | 79               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 128                                  | 129              | 130              | 133              | 136              | 138              | 140              | 90                                   | 90               | 90               | 90               | 90               | 91               | 91               |
| 13                                                       | 50 <sup>th</sup>           | 103                                  | 104              | 105              | 108              | 110              | 111              | 112              | 61                                   | 61               | 61               | 62               | 63               | 64               | 65               |
|                                                          | 90 <sup>th</sup>           | 115                                  | 116              | 118              | 121              | 124              | 126              | 126              | 74                                   | 74               | 74               | 75               | 76               | 77               | 77               |
|                                                          | 95 <sup>th</sup>           | 119                                  | 120              | 122              | 125              | 128              | 130              | 131              | 78                                   | 78               | 78               | 78               | 80               | 81               | 81               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 131                                  | 132              | 134              | 137              | 140              | 142              | 143              | 90                                   | 90               | 90               | 90               | 92               | 93               | 93               |
| 14                                                       | 50 <sup>th</sup>           | 105                                  | 106              | 109              | 111              | 112              | 113              | 113              | 60                                   | 60               | 62               | 64               | 65               | 66               | 67               |
|                                                          | 90 <sup>th</sup>           | 119                                  | 120              | 123              | 126              | 127              | 128              | 129              | 74                                   | 74               | 75               | 77               | 78               | 79               | 80               |
|                                                          | 95 <sup>th</sup>           | 123                                  | 125              | 127              | 130              | 132              | 133              | 134              | 77                                   | 78               | 79               | 81               | 82               | 83               | 84               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 135                                  | 137              | 139              | 142              | 144              | 145              | 146              | 89                                   | 90               | 91               | 93               | 94               | 95               | 96               |
| 15                                                       | 50 <sup>th</sup>           | 108                                  | 110              | 112              | 113              | 114              | 114              | 114              | 61                                   | 62               | 64               | 65               | 66               | 67               | 68               |
|                                                          | 90 <sup>th</sup>           | 123                                  | 124              | 126              | 128              | 129              | 130              | 130              | 75                                   | 76               | 78               | 79               | 80               | 81               | 81               |
|                                                          | 95 <sup>th</sup>           | 127                                  | 129              | 131              | 132              | 134              | 135              | 135              | 78                                   | 79               | 81               | 83               | 84               | 85               | 85               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 139                                  | 141              | 143              | 144              | 146              | 147              | 147              | 90                                   | 91               | 93               | 95               | 96               | 97               | 97               |
| 16                                                       | 50 <sup>th</sup>           | 111                                  | 112              | 114              | 115              | 115              | 116              | 116              | 63                                   | 64               | 66               | 67               | 68               | 69               | 69               |
|                                                          | 90 <sup>th</sup>           | 126                                  | 127              | 128              | 129              | 131              | 131              | 132              | 77                                   | 78               | 79               | 80               | 81               | 82               | 82               |
|                                                          | 95 <sup>th</sup>           | 130                                  | 131              | 133              | 134              | 135              | 136              | 137              | 80                                   | 81               | 83               | 84               | 85               | 86               | 86               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 142                                  | 143              | 145              | 146              | 147              | 148              | 149              | 92                                   | 93               | 95               | 96               | 97               | 98               | 98               |
| 17                                                       | 50 <sup>th</sup>           | 114                                  | 115              | 116              | 117              | 117              | 118              | 118              | 65                                   | 66               | 67               | 68               | 69               | 70               | 70               |
|                                                          | 90 <sup>th</sup>           | 128                                  | 129              | 130              | 131              | 132              | 133              | 134              | 78                                   | 79               | 80               | 81               | 82               | 82               | 83               |
|                                                          | 95 <sup>th</sup>           | 132                                  | 133              | 134              | 135              | 137              | 138              | 138              | 81                                   | 82               | 84               | 85               | 86               | 86               | 87               |
|                                                          | 95 <sup>th</sup> + 12 mmHg | 144                                  | 145              | 146              | 147              | 149              | 150              | 150              | 93                                   | 94               | 96               | 97               | 98               | 98               | 99               |

Use percentile values to stage BP readings. The 50<sup>th</sup>, 90<sup>th</sup>, and 95<sup>th</sup> percentiles were derived by using quantile regression on the basis of normal-weight children (BMI <85<sup>th</sup> percentile).

| Age (y) | BP Percentile              | SBP (mm Hg)                          |                  |                  |                  |                  |                  |                  | DBP (mm Hg)                          |                  |                  |                  |                  |                  |                  |
|---------|----------------------------|--------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|--------------------------------------|------------------|------------------|------------------|------------------|------------------|------------------|
|         |                            | Height Percentile or Measured Height |                  |                  |                  |                  |                  |                  | Height Percentile or Measured Height |                  |                  |                  |                  |                  |                  |
|         |                            | 5 <sup>th</sup>                      | 10 <sup>th</sup> | 25 <sup>th</sup> | 50 <sup>th</sup> | 75 <sup>th</sup> | 90 <sup>th</sup> | 95 <sup>th</sup> | 5 <sup>th</sup>                      | 10 <sup>th</sup> | 25 <sup>th</sup> | 50 <sup>th</sup> | 75 <sup>th</sup> | 90 <sup>th</sup> | 95 <sup>th</sup> |
| 1       | 50 <sup>th</sup>           | 84                                   | 85               | 86               | 86               | 87               | 88               | 88               | 41                                   | 42               | 42               | 43               | 44               | 45               | 46               |
|         | 90 <sup>th</sup>           | 98                                   | 99               | 99               | 100              | 101              | 102              | 102              | 54                                   | 55               | 56               | 56               | 57               | 58               | 58               |
|         | 95 <sup>th</sup>           | 101                                  | 102              | 102              | 103              | 104              | 105              | 105              | 59                                   | 59               | 60               | 60               | 61               | 62               | 62               |
|         | 95 <sup>th</sup> + 12 mmHg | 113                                  | 114              | 114              | 115              | 116              | 117              | 117              | 71                                   | 71               | 72               | 72               | 73               | 74               | 74               |
| 2       | 50 <sup>th</sup>           | 87                                   | 87               | 88               | 89               | 90               | 91               | 91               | 45                                   | 46               | 47               | 48               | 49               | 50               | 51               |
|         | 90 <sup>th</sup>           | 101                                  | 101              | 102              | 103              | 104              | 105              | 106              | 58                                   | 58               | 59               | 60               | 61               | 62               | 62               |
|         | 95 <sup>th</sup>           | 104                                  | 105              | 106              | 106              | 107              | 108              | 109              | 62                                   | 63               | 63               | 64               | 65               | 66               | 66               |
|         | 95 <sup>th</sup> + 12 mmHg | 116                                  | 117              | 118              | 118              | 119              | 120              | 121              | 74                                   | 75               | 75               | 76               | 77               | 78               | 78               |
| 3       | 50 <sup>th</sup>           | 88                                   | 89               | 89               | 90               | 91               | 92               | 93               | 48                                   | 48               | 49               | 50               | 51               | 53               | 53               |
|         | 90 <sup>th</sup>           | 102                                  | 103              | 104              | 104              | 105              | 106              | 107              | 60                                   | 61               | 61               | 62               | 63               | 64               | 65               |
|         | 95 <sup>th</sup>           | 106                                  | 106              | 107              | 108              | 109              | 110              | 110              | 64                                   | 65               | 65               | 66               | 67               | 68               | 69               |
|         | 95 <sup>th</sup> + 12 mmHg | 118                                  | 118              | 119              | 120              | 121              | 122              | 122              | 76                                   | 77               | 77               | 78               | 79               | 80               | 81               |
| 4       | 50 <sup>th</sup>           | 89                                   | 90               | 91               | 92               | 93               | 94               | 94               | 50                                   | 51               | 51               | 53               | 54               | 55               | 55               |
|         | 90 <sup>th</sup>           | 103                                  | 104              | 105              | 106              | 107              | 108              | 108              | 62                                   | 63               | 64               | 65               | 66               | 67               | 67               |
|         | 95 <sup>th</sup>           | 107                                  | 108              | 109              | 109              | 110              | 111              | 112              | 66                                   | 67               | 68               | 69               | 70               | 70               | 71               |
|         | 95 <sup>th</sup> + 12 mmHg | 119                                  | 120              | 121              | 121              | 122              | 123              | 124              | 78                                   | 79               | 80               | 81               | 82               | 82               | 83               |
| 5       | 50 <sup>th</sup>           | 90                                   | 91               | 92               | 93               | 94               | 95               | 96               | 52                                   | 52               | 53               | 55               | 56               | 57               | 57               |
|         | 90 <sup>th</sup>           | 104                                  | 105              | 106              | 107              | 108              | 109              | 110              | 64                                   | 65               | 66               | 67               | 68               | 69               | 70               |
|         | 95 <sup>th</sup>           | 108                                  | 109              | 109              | 110              | 111              | 112              | 113              | 68                                   | 69               | 70               | 71               | 72               | 73               | 73               |
|         | 95 <sup>th</sup> + 12 mmHg | 120                                  | 121              | 121              | 122              | 123              | 124              | 125              | 80                                   | 81               | 82               | 83               | 84               | 85               | 85               |
| 6       | 50 <sup>th</sup>           | 92                                   | 92               | 93               | 94               | 96               | 97               | 97               | 54                                   | 54               | 55               | 56               | 57               | 58               | 59               |
|         | 90 <sup>th</sup>           | 105                                  | 106              | 107              | 108              | 109              | 110              | 111              | 67                                   | 67               | 68               | 69               | 70               | 71               | 71               |
|         | 95 <sup>th</sup>           | 109                                  | 109              | 110              | 111              | 112              | 113              | 114              | 70                                   | 71               | 72               | 72               | 73               | 74               | 74               |
|         | 95 <sup>th</sup> + 12 mmHg | 121                                  | 121              | 122              | 123              | 124              | 125              | 126              | 82                                   | 83               | 84               | 84               | 85               | 86               | 86               |
| 7       | 50 <sup>th</sup>           | 92                                   | 93               | 94               | 95               | 97               | 98               | 99               | 55                                   | 55               | 56               | 57               | 58               | 59               | 60               |
|         | 90 <sup>th</sup>           | 106                                  | 106              | 107              | 109              | 110              | 111              | 112              | 68                                   | 68               | 69               | 70               | 71               | 72               | 72               |
|         | 95 <sup>th</sup>           | 109                                  | 110              | 111              | 112              | 113              | 114              | 115              | 72                                   | 72               | 73               | 73               | 74               | 74               | 75               |
|         | 95 <sup>th</sup> + 12 mmHg | 121                                  | 122              | 123              | 124              | 125              | 126              | 127              | 84                                   | 84               | 85               | 85               | 86               | 86               | 87               |
| 8       | 50 <sup>th</sup>           | 93                                   | 94               | 95               | 97               | 98               | 99               | 100              | 56                                   | 56               | 57               | 59               | 60               | 61               | 61               |
|         | 90 <sup>th</sup>           | 107                                  | 107              | 108              | 110              | 111              | 112              | 113              | 69                                   | 70               | 71               | 72               | 72               | 73               | 73               |
|         | 95 <sup>th</sup>           | 110                                  | 111              | 112              | 113              | 115              | 116              | 117              | 72                                   | 73               | 74               | 74               | 75               | 75               | 75               |
|         | 95 <sup>th</sup> + 12 mmHg | 112                                  | 123              | 124              | 125              | 127              | 128              | 129              | 84                                   | 85               | 86               | 86               | 87               | 87               | 87               |
| 9       | 50 <sup>th</sup>           | 95                                   | 95               | 97               | 98               | 99               | 100              | 101              | 57                                   | 58               | 59               | 60               | 60               | 61               | 61               |
|         | 90 <sup>th</sup>           | 108                                  | 108              | 109              | 111              | 112              | 113              | 114              | 71                                   | 71               | 72               | 73               | 73               | 73               | 73               |
|         | 95 <sup>th</sup>           | 112                                  | 112              | 113              | 114              | 116              | 117              | 118              | 74                                   | 74               | 75               | 75               | 75               | 75               | 75               |
|         | 95 <sup>th</sup> + 12 mmHg | 124                                  | 124              | 125              | 126              | 128              | 129              | 130              | 86                                   | 86               | 87               | 87               | 87               | 87               | 87               |
| 10      | 50 <sup>th</sup>           | 96                                   | 97               | 98               | 99               | 101              | 102              | 103              | 58                                   | 59               | 59               | 60               | 61               | 61               | 62               |
|         | 90 <sup>th</sup>           | 109                                  | 110              | 111              | 112              | 113              | 115              | 116              | 72                                   | 73               | 73               | 73               | 73               | 73               | 73               |
|         | 95 <sup>th</sup>           | 113                                  | 114              | 114              | 116              | 117              | 119              | 120              | 75                                   | 75               | 76               | 76               | 76               | 76               | 76               |
|         | 95 <sup>th</sup> + 12 mmHg | 125                                  | 126              | 126              | 128              | 129              | 131              | 132              | 87                                   | 87               | 88               | 88               | 88               | 88               | 88               |
| 11      | 50 <sup>th</sup>           | 98                                   | 99               | 101              | 102              | 104              | 105              | 106              | 60                                   | 60               | 60               | 61               | 62               | 63               | 64               |
|         | 90 <sup>th</sup>           | 111                                  | 112              | 113              | 114              | 116              | 118              | 120              | 74                                   | 74               | 74               | 74               | 74               | 75               | 75               |
|         | 95 <sup>th</sup>           | 115                                  | 116              | 117              | 118              | 120              | 123              | 124              | 76                                   | 77               | 77               | 77               | 77               | 77               | 77               |
|         | 95 <sup>th</sup> + 12 mmHg | 127                                  | 128              | 129              | 130              | 132              | 135              | 136              | 88                                   | 89               | 89               | 89               | 89               | 89               | 89               |
| 12      | 50 <sup>th</sup>           | 102                                  | 102              | 104              | 105              | 107              | 108              | 108              | 61                                   | 61               | 61               | 62               | 64               | 65               | 65               |
|         | 90 <sup>th</sup>           | 114                                  | 115              | 116              | 118              | 120              | 122              | 122              | 75                                   | 75               | 75               | 75               | 76               | 76               | 76               |
|         | 95 <sup>th</sup>           | 118                                  | 119              | 120              | 122              | 124              | 125              | 126              | 78                                   | 78               | 78               | 78               | 79               | 79               | 79               |
|         | 95 <sup>th</sup> + 12 mmHg | 130                                  | 131              | 132              | 134              | 136              | 137              | 138              | 90                                   | 90               | 90               | 90               | 91               | 91               | 91               |
| 13      | 50 <sup>th</sup>           | 104                                  | 105              | 106              | 107              | 108              | 108              | 109              | 62                                   | 62               | 63               | 64               | 65               | 65               | 66               |
|         | 90 <sup>th</sup>           | 116                                  | 117              | 119              | 121              | 122              | 123              | 123              | 75                                   | 75               | 75               | 76               | 76               | 76               | 76               |
|         | 95 <sup>th</sup>           | 121                                  | 122              | 123              | 124              | 126              | 126              | 127              | 79                                   | 79               | 79               | 79               | 80               | 80               | 81               |
|         | 95 <sup>th</sup> + 12 mmHg | 133                                  | 134              | 135              | 136              | 138              | 138              | 139              | 91                                   | 91               | 91               | 91               | 92               | 92               | 93               |
| 14      | 50 <sup>th</sup>           | 105                                  | 106              | 107              | 108              | 109              | 109              | 109              | 63                                   | 63               | 64               | 65               | 66               | 66               | 66               |
|         | 90 <sup>th</sup>           | 118                                  | 118              | 120              | 122              | 123              | 123              | 123              | 76                                   | 76               | 76               | 76               | 77               | 77               | 77               |
|         | 95 <sup>th</sup>           | 123                                  | 123              | 124              | 125              | 126              | 127              | 127              | 80                                   | 80               | 80               | 80               | 81               | 81               | 82               |
|         | 95 <sup>th</sup> + 12 mmHg | 135                                  | 135              | 136              | 137              | 138              | 139              | 139              | 92                                   | 92               | 92               | 92               | 93               | 93               | 94               |
| 15      | 50 <sup>th</sup>           | 105                                  | 106              | 107              | 108              | 109              | 109              | 109              | 64                                   | 64               | 64               | 65               | 66               | 67               | 67               |
|         | 90 <sup>th</sup>           | 118                                  | 119              | 121              | 122              | 123              | 123              | 124              | 76                                   | 76               | 76               | 77               | 77               | 78               | 78               |
|         | 95 <sup>th</sup>           | 124                                  | 124              | 125              | 126              | 127              | 127              | 128              | 80                                   | 80               | 80               | 81               | 82               | 82               | 82               |
|         | 95 <sup>th</sup> + 12 mmHg | 136                                  | 136              | 137              | 138              | 139              | 139              | 140              | 92                                   | 92               | 92               | 93               | 94               | 94               | 94               |
| 16      | 50 <sup>th</sup>           | 106                                  | 107              | 108              | 109              | 109              | 110              | 110              | 64                                   | 64               | 65               | 66               | 66               | 67               | 67               |
|         | 90 <sup>th</sup>           | 119                                  | 120              | 122              | 123              | 124              | 124              | 124              | 76                                   | 76               | 76               | 77               | 78               | 78               | 78               |
|         | 95 <sup>th</sup>           | 124                                  | 125              | 125              | 127              | 127              | 128              | 128              | 80                                   | 80               | 80               | 81               | 82               | 82               | 82               |
|         | 95 <sup>th</sup> + 12 mmHg | 136                                  | 137              | 137              | 139              | 139              | 140              | 140              | 92                                   | 92               | 92               | 93               | 94               | 94               | 94               |
| 17      | 50 <sup>th</sup>           | 107                                  | 108              | 109              | 110              | 110              | 110              | 111              | 64                                   | 64               | 65               | 66               | 66               | 66               | 67               |
|         | 90 <sup>th</sup>           | 120                                  | 121              | 123              | 124              | 124              | 125              | 125              | 76                                   | 76               | 77               | 77               | 78               | 78               | 78               |
|         | 95 <sup>th</sup>           | 125                                  | 125              | 126              | 127              | 128              | 128              | 128              | 80                                   | 80               | 80               | 81               | 82               | 82               | 82               |
|         | 95 <sup>th</sup> + 12 mmHg | 137                                  | 137              | 138              | 139              | 140              | 140              | 140              | 92                                   | 92               | 92               | 93               | 94               | 94               | 94               |

Use percentile values to stage BP readings. The 50<sup>th</sup>, 90<sup>th</sup>, and 95<sup>th</sup> percentiles were derived by using quantile regression on the basis of normal-weight children (BMI <85<sup>th</sup> percentile).

**Appendix 2: Normal Paediatric Heart Rate Ranges**

| Age       | Guide weight (kg) |       | HR beats per minute<br>5 <sup>th</sup> – 95 <sup>th</sup> centile |
|-----------|-------------------|-------|-------------------------------------------------------------------|
|           | Boys              | Girls |                                                                   |
| Birth     | 3.5               | 3.5   | 120 – 170                                                         |
| 1 month   | 4.5               | 4.5   |                                                                   |
| 3 months  | 6.5               | 6     | 115 – 160                                                         |
| 6 months  | 8                 | 7     | 110 – 160                                                         |
| 12 months | 9.5               | 9     |                                                                   |
| 18 months | 11                | 10    | 100 – 155                                                         |
| 2 years   | 12                | 12    | 100 – 150                                                         |
| 3 years   | 14                | 14    | 90 – 140                                                          |
| 4 years   | 16                | 16    | 80 – 135                                                          |
| 5 years   | 18                | 18    |                                                                   |
| 6 years   | 21                | 20    | 80 – 130                                                          |
| 7 years   | 23                | 22    |                                                                   |
| 8 years   | 25                | 25    | 70 – 120                                                          |
| 9 years   | 28                | 28    |                                                                   |
| 10 years  | 31                | 32    |                                                                   |
| 11 years  | 35                | 35    |                                                                   |
| 12 years  | 43                | 43    | 65 – 115                                                          |
| 14 years  | 50                | 50    | 60 – 110                                                          |

**Appendix 3: Normal Heart Rates**

| <u>Normal heart rates in children</u> |                   |                      |
|---------------------------------------|-------------------|----------------------|
| Age                                   | Awake<br>rate/min | Sleeping<br>rate/min |
| Neonate                               | 100-180           | 80-160               |
| Infant (6 mo.)                        | 100-160           | 75-160               |
| Toddler                               | 80-110            | 60-90                |
| Pre-schooler                          | 70-110            | 60-90                |
| School-age                            | 65-110            | 60-90                |
| Adolescent                            | 60-90             | 50-90                |

| Version Control- <b>Blood Pressure and Heart Rate Monitoring in Children</b> |              |            |         |
|------------------------------------------------------------------------------|--------------|------------|---------|
| Version                                                                      | Author(s)    | Date       | Changes |
| 1.1                                                                          | Shary Walker | 17/09/2020 |         |
|                                                                              |              |            |         |
|                                                                              |              |            |         |