

## Management of dyslipidaemia in HIV infected children: rationale for treatment algorithm

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### Background

The introduction of Antiretroviral therapy (ART) for treatment of paediatric HIV infection has markedly improved survival. However, both HIV and ART are associated with metabolic complications and increased risk of cardiovascular disease (CVD).<sup>1,2</sup> Lipid profiles in some infected children can be similar to those with familial hyperlipidemia who usually develop premature atherosclerotic disease in adulthood.<sup>3</sup>

Observational studies have demonstrated a clear correlation between lipoprotein disorders and the onset and severity of atherosclerosis in children, adolescents, and young adults.<sup>4-6</sup> Over the same time period a steep rise in obesity prevalence has led to an increase in children with dyslipidaemia. HIV is recognised as a disease that is associated with moderately increased CVD risk.<sup>7</sup> HIV and obesity can therefore be considered concomitant epidemics that increase CVD risk in children.

### Justification

Evidence from observational studies suggest that identification and treatment of dyslipidaemia in HIV infected children could reduce CVD risk.<sup>8</sup> However, in the UK, screening recommendations for paediatric hyperlipidaemia are available for children with familial hyperlipidaemia only.<sup>9</sup> Recent guidelines from the American National Heart Lung and Blood Institute recommend the use of single cut-offs to identify children with abnormal fasting lipid and lipoprotein concentrations (Table 1).<sup>10</sup>

**Table 1** Cut Offs for Total and LDL Cholesterol Concentration in Children and Adolescents

| Category          | Acceptable (mmol/l) | Borderline (mmol/l) | High (mmol/l) |
|-------------------|---------------------|---------------------|---------------|
| TC                | <4.4                | 4.4 - 4.9           | ≥5.0          |
| LDL-C             | <2.8                | 2.8 – 2.9           | ≥3.0          |
| TG<br>0-9 years   | <0.9                | 0.9 – 1.0           | ≥1.1          |
| TG<br>10-19 years | <1.0                | 1.0 – 1.4           | ≥1.5          |
| HDL-C             | >1.2                | 1.0 – 1.2           | <1.0          |
| Non-HDL-C         | <3.1                | 3.1 - 3.6           | ≥3.7          |

*Adapted from NHLIB guidelines for children and adolescents (2012)*<sup>10</sup>

## **Recommendations**

Lipid screening should be routinely carried out in all HIV infected children in the UK to identify children at increased risk of premature CVD at least annually. In the absence of guidelines from the UK it is recommended that cut offs identified from the US NHANES study are used. A suggested pathway for screening, based on NHLBI guidelines,<sup>10</sup> is described in the attached algorithm (Fig 1). It is recommended that children undergo an annual nutritional review (Appendix 1, for use by dietitians) and are referred for advice on diet and lifestyle for lipid modification if there are any concerns. (Appendix 2, for use by dietitians).

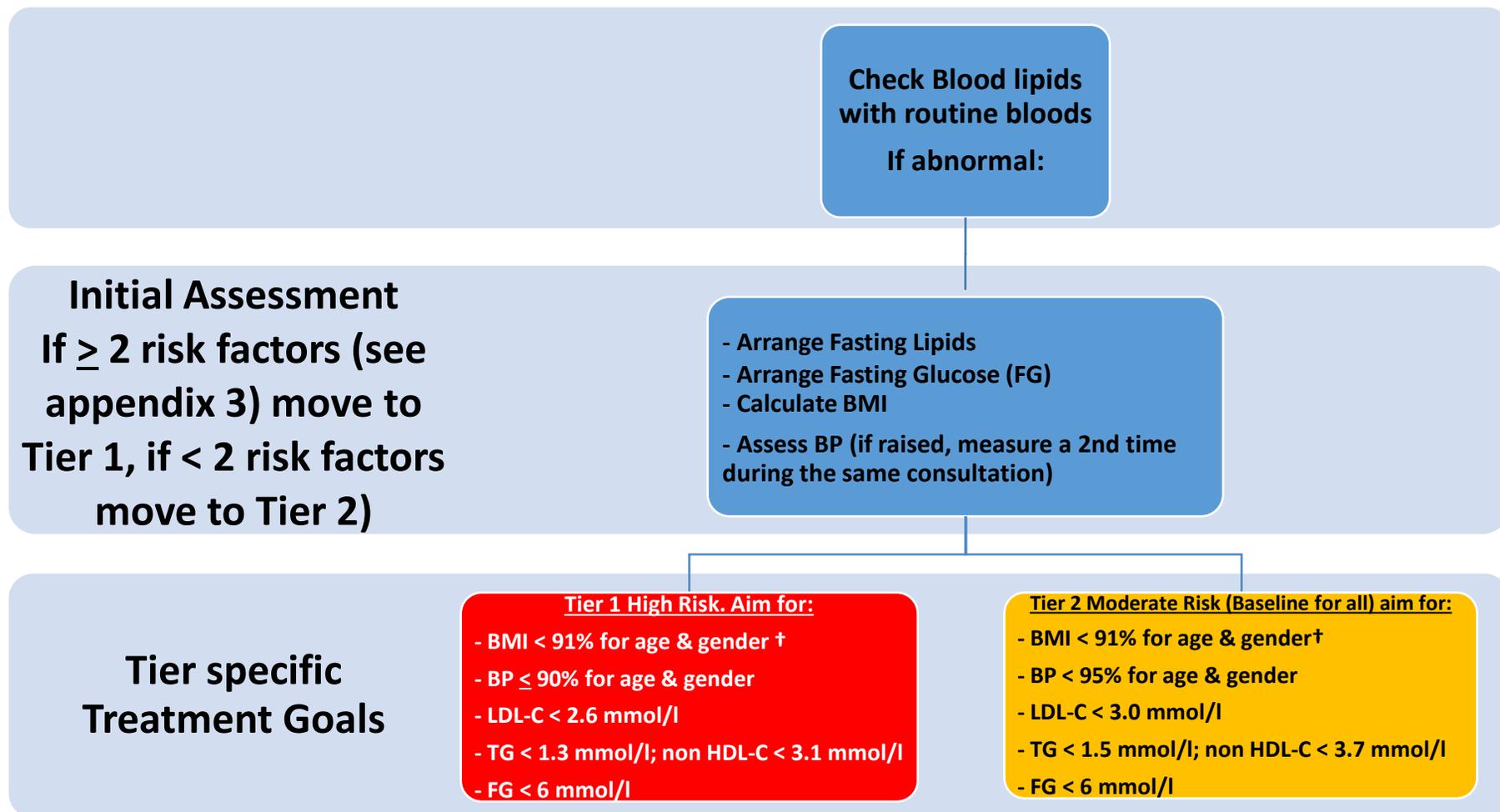
Pharmacologic intervention could be considered in children only  $\geq 10$  years either with severe dyslipidaemia or borderline to raised lipids and additional risk factors, but only under guidance of physicians with experience in their use in children and with advice from network hub team (see CHINN structure) (Appendix 3).

## **Dietary Advice**

Within appropriate age- and gender-based requirements for growth and nutrition, in normal lipid level and in children with hypercholesterolemia intake of total fat can be safely limited to 30% of total calories, saturated fat intake limited to 7% to 10% of calories.

Figure 1

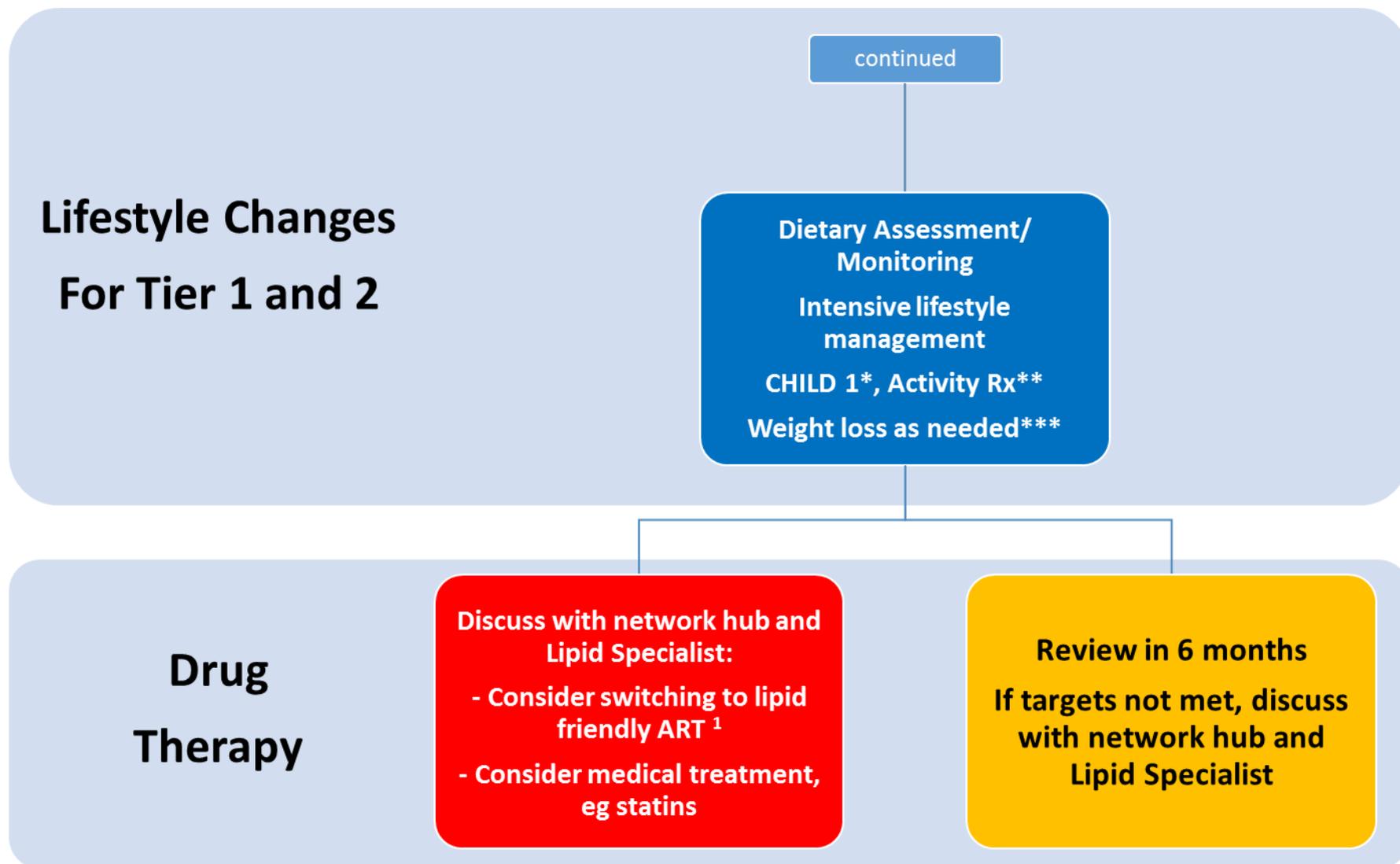
Algorithm for management of HIV associated dyslipidaemia in children aged more than 2 years



BP Centiles see Appendix 4

†According to UK-WHO Growth Reference

Continued on next page



\* CHILD 1 – Cardiovascular Health Integrated Lifestyle Diet <sup>10</sup> (Section 5)

\*\* Active Rx – Activity Recommendations <sup>10</sup> (Section 6)

\*\*\* Weight loss recommendations <sup>11</sup> (Section 1)

<sup>1</sup> Evidence for switching to lipid friendly ART is currently still inconclusive

# Appendix 1

## Example Dietetic Annual Assessment Form

|   |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
|---|----------------|----------------|-----------------|-------------------|-----------------|-----------------------------------|-------------------|--------------|-------------------|--|---------------|
| <b>Name:</b>                                      |                |                |                 | <b>DOB:</b>       |                 |                                   |                   | <b>Date:</b> |                   |  |               |
| <b>Age:</b>                                       |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| <b>Hospital No</b>                                |                |                |                 |                   |                 | <b>Current Treatment:</b>         |                   |              |                   |  |               |
| <b>Ht (cm)</b>                                    | <b>Wt (kg)</b> | <b>BMI</b>     | <b>MUAC(cm)</b> | <b>Waist (cm)</b> | <b>Hip (cm)</b> | <b>Calf (cm)</b>                  | <b>Thigh (cm)</b> |              |                   |  |               |
| <b>Centile</b>                                    | <b>Centile</b> | <b>Centile</b> | <b>Centile</b>  | <b>Centile</b>    | <b>Centile</b>  | <b>Centile</b>                    | <b>Centile</b>    |              |                   |  |               |
| <b>Skinfold (mm)</b>                              |                | <b>Triceps</b> |                 | <b>Biceps</b>     |                 | <b>Subscapular</b>                |                   |              | <b>Suprailiac</b> |  |               |
| 1   |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| 2   |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| 3   |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| <b>Mean</b>                                       |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| <b>Lipids (mmol/l) (1 = latest; 2 = previous)</b> |                | <b>Date</b>    |                 | <b>Result</b>     |                 | <b>Blood Results</b>              |                   |              | <b>Date</b>       |  | <b>Result</b> |
| TC 1  |                |                |                 |                   |                 | Hb                                |                   |              |                   |  |               |
| TC 2  |                |                |                 |                   |                 | Vit D                             |                   |              |                   |  |               |
| Refer to Figure 1                                 |                |                |                 |                   |                 | Calcium                           |                   |              |                   |  |               |
| HDL 1   |                |                |                 |                   |                 | Alk Phosphate                     |                   |              |                   |  |               |
| HDL 2   |                |                |                 |                   |                 | PTH                               |                   |              |                   |  |               |
| Refer to Figure 1                                 |                |                |                 |                   |                 | CD <sub>4</sub> No. (%)           |                   |              |                   |  |               |
| LDL 1   |                |                |                 |                   |                 | Viral load                        |                   |              |                   |  |               |
| LDL 2   |                |                |                 |                   |                 | <b>Summary and Treatment Plan</b> |                   |              |                   |  |               |
| Refer to Figure 1                                 |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| TG 1  |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| TG 2  |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |
| Refer to Figure 1                                 |                |                |                 |                   |                 |                                   |                   |              |                   |  |               |

| Diet history | Diet Summary   |
|--------------|--|
|              | <b>Meat/ Fish/Pulses:</b>  |
|              | <b>Milk/dairy:</b>   |
|              | <b>Fruit/vegetables:</b>   |
|              | <b>Butter/margarine/oil:</b>   |
|              | <b>Soluble Fibre:</b>  |
|              | <b>Drinks:</b>   |
|              | <b>Checklist:</b><br>Snacks<br>Nuts<br>Crisps<br>Cakes<br>Sweets<br>Choc<br>Biscuits<br>Sweet drinks |
|              | <b>Out of home e.g. friends/relatives/school:</b><br><br><b>Weekends/holidays:</b>                   |
|              | <b>Omega 3:</b>  |
|              | <b>Nutritional supplements:</b>  |
|              | <b>Physical Activity</b>   |
|              | <b>Agreed Goals</b>  |

## Appendix 2

### Dietary and lifestyle recommendations for targeting lipid abnormalities.

#### Reducing LDL and non-HDL cholesterol levels

Restrict proportion of total calories to:

25% to 30% from fat

≤7% from saturated fat

Replace saturated with unsaturated fats where possible

Avoid saturated fats and trans fats. Trans fatty acids are found mainly in processed foods including pies, pastries and meat products. Diets high in fat, and particularly those high in saturated and/or trans fats, are considered a risk factor for the development of atherosclerosis<sup>12</sup>.

Consider the use of foods enriched with plant sterol/stanol esters.

Increase consumption of soluble dietary fibre (present in fruits, vegetables and pulses (peas, bean and lentils) oats and barley.

#### Reducing triglyceride levels

- Restrict proportion of total calories to:

25% to 30% from fat

≤7% from saturated fat

Replace saturated fat with mono and polyunsaturated fats where possible

Avoid saturated and trans fats

Increase consumption of soluble dietary fibre

Decrease sugar intake, particularly from sugar sweetened drinks

Include foods high in omega-3 (n-3) fatty acids. Long chain n-3 fatty acids, in particular docosahexaenoic and eicosapentanoic acids found in high concentrations in fish have been shown to reduce triglyceride concentrations in many studies.<sup>13</sup>.

#### Increasing HDL-C

Increase soluble fibre intake (fruits, vegetables, pulses (peas/beans/lentils), oats and barley)

Assess and encourage appropriate physical activity levels

For age specific guidance see link below

[http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH\\_127931](http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_127931)

For further information see table 9.8 NLHBI 2011 <http://www.nhlbi.nih.gov/health-pro/guidelines/current/cardiovascular-health-pediatric-guidelines>

## Appendix 3

### Recommendations Regarding Drug Therapy for Children and Adolescents.

1. Measure and average values from the 2 most recent lipid profiles.

2. Consider changing to a more lipid friendly antiretroviral therapy if above cut offs are reached (evidence for this practice remains limited).
3. Consider medical management under the following circumstances:

- Clinical CVD.
- LDL-C  $\geq$ 4.90 mmol/L (non-HDL-C  $\geq$ 5.30 mmol/L)
- LDL-C 4.15-4.89 mmol/L (non-HDL-C 4.50-5.29 mmol/L) and either positive family history of early CVD, or  $\geq$ 1 CVD risk factors
- LDL-C 3.35-4.14 mmol/L (non-HDL-C 3.75-4.49 mmol/L) and  $\geq$ 2 risk factors (NB if triglycerides  $>$ 2.25 mmol/L, may use non-HDL-C cut offs)

**Risk factors include:**

Hypertension requiring drug therapy (BP  $>$ 99<sup>th</sup> percentile + 5mm Hg)  
Passive smoke exposure or current smoker  
BMI  $>$ 98<sup>th</sup> centile on UK-WHO Growth reference  
Diabetes and prediabetes (Type I or II).  
Physical inactivity  
Family history of CVD

The choice of statin is a matter of preference and co-medication. Individual cases should therefore be discussed with the specialist experienced in using statins in children and the Network Hub Lead. Start with the lowest dose, monitor for adverse effects, and titrate the dose upwards if therapeutic targets are not achieved.

**Therapeutic target:**

Targets should be set in consultation with a lipid specialist and the MDT and Network Hub Center.

**Abbreviations:** CVD, cardiovascular disease; HDL-C, high density lipoprotein cholesterol; LDL-C, low density lipoprotein cholesterol; RF/RC, risk factor/risk condition

**Appendix 4** (from NHLBI <sup>10</sup>)

**Blood Pressure Levels for Boys by Age and Height Percentile**

| Age (Year) | BP Percentile ↓ | Systolic BP (mmHg)       |      |      |      |      |      |      | Diastolic BP (mmHg)      |      |      |      |      |      |      |
|------------|-----------------|--------------------------|------|------|------|------|------|------|--------------------------|------|------|------|------|------|------|
|            |                 | ← Percentile of Height → |      |      |      |      |      |      | ← Percentile of Height → |      |      |      |      |      |      |
|            |                 | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th |
| 1          | 50th            | 80                       | 81   | 83   | 85   | 87   | 88   | 89   | 34                       | 35   | 36   | 37   | 38   | 39   | 39   |
|            | 90th            | 94                       | 95   | 97   | 99   | 100  | 102  | 103  | 49                       | 50   | 51   | 52   | 53   | 53   | 54   |
|            | 95th            | 98                       | 99   | 101  | 103  | 104  | 106  | 106  | 54                       | 54   | 55   | 56   | 57   | 58   | 58   |
|            | 99th            | 105                      | 106  | 108  | 110  | 112  | 113  | 114  | 61                       | 62   | 63   | 64   | 65   | 66   | 66   |
| 2          | 50th            | 84                       | 85   | 87   | 88   | 90   | 92   | 92   | 39                       | 40   | 41   | 42   | 43   | 44   | 44   |
|            | 90th            | 97                       | 99   | 100  | 102  | 104  | 105  | 106  | 54                       | 55   | 56   | 57   | 58   | 58   | 59   |
|            | 95th            | 101                      | 102  | 104  | 106  | 108  | 109  | 110  | 59                       | 59   | 60   | 61   | 62   | 63   | 63   |
|            | 99th            | 109                      | 110  | 111  | 113  | 115  | 117  | 117  | 66                       | 67   | 68   | 69   | 70   | 71   | 71   |
| 3          | 50th            | 86                       | 87   | 89   | 91   | 93   | 94   | 95   | 44                       | 44   | 45   | 46   | 47   | 48   | 48   |
|            | 90th            | 100                      | 101  | 103  | 105  | 107  | 108  | 109  | 59                       | 59   | 60   | 61   | 62   | 63   | 63   |
|            | 95th            | 104                      | 105  | 107  | 109  | 110  | 112  | 113  | 63                       | 63   | 64   | 65   | 66   | 67   | 67   |
|            | 99th            | 111                      | 112  | 114  | 116  | 118  | 119  | 120  | 71                       | 71   | 72   | 73   | 74   | 75   | 75   |
| 4          | 50th            | 88                       | 89   | 91   | 93   | 95   | 96   | 97   | 47                       | 48   | 49   | 50   | 51   | 51   | 52   |
|            | 90th            | 102                      | 103  | 105  | 107  | 109  | 110  | 111  | 62                       | 63   | 64   | 65   | 66   | 66   | 67   |
|            | 95th            | 106                      | 107  | 109  | 111  | 112  | 114  | 115  | 66                       | 67   | 68   | 69   | 70   | 71   | 71   |
|            | 99th            | 113                      | 114  | 116  | 118  | 120  | 121  | 122  | 74                       | 75   | 76   | 77   | 78   | 78   | 79   |
| 5          | 50th            | 90                       | 91   | 93   | 95   | 96   | 98   | 98   | 50                       | 51   | 52   | 53   | 54   | 55   | 55   |
|            | 90th            | 104                      | 105  | 106  | 108  | 110  | 111  | 112  | 65                       | 66   | 67   | 68   | 69   | 69   | 70   |
|            | 95th            | 108                      | 109  | 110  | 112  | 114  | 115  | 116  | 69                       | 70   | 71   | 72   | 73   | 74   | 74   |
|            | 99th            | 115                      | 116  | 118  | 120  | 121  | 123  | 123  | 77                       | 78   | 79   | 80   | 81   | 81   | 82   |
| 6          | 50th            | 91                       | 92   | 94   | 96   | 98   | 99   | 100  | 53                       | 53   | 54   | 55   | 56   | 57   | 57   |
|            | 90th            | 105                      | 106  | 108  | 110  | 111  | 113  | 113  | 68                       | 68   | 69   | 70   | 71   | 72   | 72   |
|            | 95th            | 109                      | 110  | 112  | 114  | 115  | 117  | 117  | 72                       | 72   | 73   | 74   | 75   | 76   | 76   |
|            | 99th            | 116                      | 117  | 119  | 121  | 123  | 124  | 125  | 80                       | 80   | 81   | 82   | 83   | 84   | 84   |
| 7          | 50th            | 92                       | 94   | 95   | 97   | 99   | 100  | 101  | 55                       | 55   | 56   | 57   | 58   | 59   | 59   |
|            | 90th            | 106                      | 107  | 109  | 111  | 113  | 114  | 115  | 70                       | 70   | 71   | 72   | 73   | 74   | 74   |
|            | 95th            | 110                      | 111  | 113  | 115  | 117  | 118  | 119  | 74                       | 74   | 75   | 76   | 77   | 78   | 78   |
|            | 99th            | 117                      | 118  | 120  | 122  | 124  | 125  | 126  | 82                       | 82   | 83   | 84   | 85   | 86   | 86   |
| 8          | 50th            | 94                       | 95   | 97   | 99   | 100  | 102  | 102  | 56                       | 57   | 58   | 59   | 60   | 60   | 61   |
|            | 90th            | 107                      | 109  | 110  | 112  | 114  | 115  | 116  | 71                       | 72   | 72   | 73   | 74   | 75   | 76   |
|            | 95th            | 111                      | 112  | 114  | 116  | 118  | 119  | 120  | 75                       | 76   | 77   | 78   | 79   | 79   | 80   |
|            | 99th            | 119                      | 120  | 122  | 123  | 125  | 127  | 127  | 83                       | 84   | 85   | 86   | 87   | 87   | 88   |
| 9          | 50th            | 95                       | 96   | 98   | 100  | 102  | 103  | 104  | 57                       | 58   | 59   | 60   | 61   | 61   | 62   |
|            | 90th            | 109                      | 110  | 112  | 114  | 115  | 117  | 118  | 72                       | 73   | 74   | 75   | 76   | 76   | 77   |
|            | 95th            | 113                      | 114  | 116  | 118  | 119  | 121  | 121  | 76                       | 77   | 78   | 79   | 80   | 81   | 81   |
|            | 99th            | 120                      | 121  | 123  | 125  | 127  | 128  | 129  | 84                       | 85   | 86   | 87   | 88   | 88   | 89   |
| 10         | 50th            | 97                       | 98   | 100  | 102  | 103  | 105  | 106  | 58                       | 59   | 60   | 61   | 61   | 62   | 63   |
|            | 90th            | 111                      | 112  | 114  | 115  | 117  | 119  | 119  | 73                       | 73   | 74   | 75   | 76   | 77   | 78   |
|            | 95th            | 115                      | 116  | 117  | 119  | 121  | 122  | 123  | 77                       | 78   | 79   | 80   | 81   | 81   | 82   |
|            | 99th            | 122                      | 123  | 125  | 127  | 128  | 130  | 130  | 85                       | 86   | 86   | 88   | 88   | 89   | 90   |

## Blood Pressure Levels for Boys by Age and Height Percentile (Continued)

| Age<br>(Year) | BP<br>Percentile<br>↓ | Systolic BP (mmHg)       |      |      |      |      |      |      | Diastolic BP (mmHg)      |      |      |      |      |      |      |
|---------------|-----------------------|--------------------------|------|------|------|------|------|------|--------------------------|------|------|------|------|------|------|
|               |                       | ← Percentile of Height → |      |      |      |      |      |      | ← Percentile of Height → |      |      |      |      |      |      |
|               |                       | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th |
| 11            | 50th                  | 99                       | 100  | 102  | 104  | 105  | 107  | 107  | 59                       | 59   | 60   | 61   | 62   | 63   | 63   |
|               | 90th                  | 113                      | 114  | 115  | 117  | 119  | 120  | 121  | 74                       | 74   | 75   | 76   | 77   | 78   | 78   |
|               | 95th                  | 117                      | 118  | 119  | 121  | 123  | 124  | 125  | 78                       | 78   | 79   | 80   | 81   | 82   | 82   |
|               | 99th                  | 124                      | 125  | 127  | 129  | 130  | 132  | 132  | 86                       | 86   | 87   | 88   | 89   | 90   | 90   |
| 12            | 50th                  | 101                      | 102  | 104  | 106  | 108  | 109  | 110  | 59                       | 60   | 61   | 62   | 63   | 63   | 64   |
|               | 90th                  | 115                      | 116  | 118  | 120  | 121  | 123  | 123  | 74                       | 75   | 75   | 76   | 77   | 78   | 79   |
|               | 95th                  | 119                      | 120  | 122  | 123  | 125  | 127  | 127  | 78                       | 79   | 80   | 81   | 82   | 82   | 83   |
|               | 99th                  | 126                      | 127  | 129  | 131  | 133  | 134  | 135  | 86                       | 87   | 88   | 89   | 90   | 90   | 91   |
| 13            | 50th                  | 104                      | 105  | 106  | 108  | 110  | 111  | 112  | 60                       | 60   | 61   | 62   | 63   | 64   | 64   |
|               | 90th                  | 117                      | 118  | 120  | 122  | 124  | 125  | 126  | 75                       | 75   | 76   | 77   | 78   | 79   | 79   |
|               | 95th                  | 121                      | 122  | 124  | 126  | 128  | 129  | 130  | 79                       | 79   | 80   | 81   | 82   | 83   | 83   |
|               | 99th                  | 128                      | 130  | 131  | 133  | 135  | 136  | 137  | 87                       | 87   | 88   | 89   | 90   | 91   | 91   |
| 14            | 50th                  | 106                      | 107  | 109  | 111  | 113  | 114  | 115  | 60                       | 61   | 62   | 63   | 64   | 65   | 65   |
|               | 90th                  | 120                      | 121  | 123  | 125  | 126  | 128  | 128  | 75                       | 76   | 77   | 78   | 79   | 79   | 80   |
|               | 95th                  | 124                      | 125  | 127  | 128  | 130  | 132  | 132  | 80                       | 80   | 81   | 82   | 83   | 84   | 84   |
|               | 99th                  | 131                      | 132  | 134  | 136  | 138  | 139  | 140  | 87                       | 88   | 89   | 90   | 91   | 92   | 92   |
| 15            | 50th                  | 109                      | 110  | 112  | 113  | 115  | 117  | 117  | 61                       | 62   | 63   | 64   | 65   | 66   | 66   |
|               | 90th                  | 122                      | 124  | 125  | 127  | 129  | 130  | 131  | 76                       | 77   | 78   | 79   | 80   | 80   | 81   |
|               | 95th                  | 126                      | 127  | 129  | 131  | 133  | 134  | 135  | 81                       | 81   | 82   | 83   | 84   | 85   | 85   |
|               | 99th                  | 134                      | 135  | 136  | 138  | 140  | 142  | 142  | 88                       | 89   | 90   | 91   | 92   | 93   | 93   |
| 16            | 50th                  | 111                      | 112  | 114  | 116  | 118  | 119  | 120  | 63                       | 63   | 64   | 65   | 66   | 67   | 67   |
|               | 90th                  | 125                      | 126  | 128  | 130  | 131  | 133  | 134  | 78                       | 78   | 79   | 80   | 81   | 82   | 82   |
|               | 95th                  | 129                      | 130  | 132  | 134  | 135  | 137  | 137  | 82                       | 83   | 83   | 84   | 85   | 86   | 87   |
|               | 99th                  | 136                      | 137  | 139  | 141  | 143  | 144  | 145  | 90                       | 90   | 91   | 92   | 93   | 94   | 94   |
| 17            | 50th                  | 114                      | 115  | 116  | 118  | 120  | 121  | 122  | 65                       | 66   | 66   | 67   | 68   | 69   | 70   |
|               | 90th                  | 127                      | 128  | 130  | 132  | 134  | 135  | 136  | 80                       | 80   | 81   | 82   | 83   | 84   | 84   |
|               | 95th                  | 131                      | 132  | 134  | 136  | 138  | 139  | 140  | 84                       | 85   | 86   | 87   | 87   | 88   | 89   |
|               | 99th                  | 139                      | 140  | 141  | 143  | 145  | 146  | 147  | 92                       | 93   | 93   | 94   | 95   | 96   | 97   |

BP, blood pressure

\* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B-1 allow one to compute BP Z-scores and percentiles for boys with height percentiles given in Table 3 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2-4 described in Appendix B. For children with height percentiles other than these, follow steps 1-4 as described in Appendix B.

## Blood Pressure Levels for Girls by Age and Height Percentile

| Age<br>(Year) | BP<br>Percentile<br>↓ | Systolic BP (mmHg)       |      |      |      |      |      |      | Diastolic BP (mmHg)      |      |      |      |      |      |      |
|---------------|-----------------------|--------------------------|------|------|------|------|------|------|--------------------------|------|------|------|------|------|------|
|               |                       | ← Percentile of Height → |      |      |      |      |      |      | ← Percentile of Height → |      |      |      |      |      |      |
|               |                       | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th |
| 1             | 50th                  | 83                       | 84   | 85   | 86   | 88   | 89   | 90   | 38                       | 39   | 39   | 40   | 41   | 41   | 42   |
|               | 90th                  | 97                       | 97   | 98   | 100  | 101  | 102  | 103  | 52                       | 53   | 53   | 54   | 55   | 55   | 56   |
|               | 95th                  | 100                      | 101  | 102  | 104  | 105  | 106  | 107  | 56                       | 57   | 57   | 58   | 59   | 59   | 60   |
|               | 99th                  | 108                      | 108  | 109  | 111  | 112  | 113  | 114  | 64                       | 64   | 65   | 65   | 66   | 67   | 67   |
| 2             | 50th                  | 85                       | 85   | 87   | 88   | 89   | 91   | 91   | 43                       | 44   | 44   | 45   | 46   | 46   | 47   |
|               | 90th                  | 98                       | 99   | 100  | 101  | 103  | 104  | 105  | 57                       | 58   | 58   | 59   | 60   | 61   | 61   |
|               | 95th                  | 102                      | 103  | 104  | 105  | 107  | 108  | 109  | 61                       | 62   | 62   | 63   | 64   | 65   | 65   |
|               | 99th                  | 109                      | 110  | 111  | 112  | 114  | 115  | 116  | 69                       | 69   | 70   | 70   | 71   | 72   | 72   |
| 3             | 50th                  | 86                       | 87   | 88   | 89   | 91   | 92   | 93   | 47                       | 48   | 48   | 49   | 50   | 50   | 51   |
|               | 90th                  | 100                      | 100  | 102  | 103  | 104  | 106  | 106  | 61                       | 62   | 62   | 63   | 64   | 64   | 65   |
|               | 95th                  | 104                      | 104  | 105  | 107  | 108  | 109  | 110  | 65                       | 66   | 66   | 67   | 68   | 68   | 69   |
|               | 99th                  | 111                      | 111  | 113  | 114  | 115  | 116  | 117  | 73                       | 73   | 74   | 74   | 75   | 76   | 76   |
| 4             | 50th                  | 88                       | 88   | 90   | 91   | 92   | 94   | 94   | 50                       | 50   | 51   | 52   | 52   | 53   | 54   |
|               | 90th                  | 101                      | 102  | 103  | 104  | 106  | 107  | 108  | 64                       | 64   | 65   | 66   | 67   | 67   | 68   |
|               | 95th                  | 105                      | 106  | 107  | 108  | 110  | 111  | 112  | 68                       | 68   | 69   | 70   | 71   | 71   | 72   |
|               | 99th                  | 112                      | 113  | 114  | 115  | 117  | 118  | 119  | 76                       | 76   | 76   | 77   | 78   | 79   | 79   |
| 5             | 50th                  | 89                       | 90   | 91   | 93   | 94   | 95   | 96   | 52                       | 53   | 53   | 54   | 55   | 55   | 56   |
|               | 90th                  | 103                      | 103  | 105  | 106  | 107  | 109  | 109  | 66                       | 67   | 67   | 68   | 69   | 69   | 70   |
|               | 95th                  | 107                      | 107  | 108  | 110  | 111  | 112  | 113  | 70                       | 71   | 71   | 72   | 73   | 73   | 74   |
|               | 99th                  | 114                      | 114  | 116  | 117  | 118  | 120  | 120  | 78                       | 78   | 79   | 79   | 80   | 81   | 81   |
| 6             | 50th                  | 91                       | 92   | 93   | 94   | 96   | 97   | 98   | 54                       | 54   | 55   | 56   | 56   | 57   | 58   |
|               | 90th                  | 104                      | 105  | 106  | 108  | 109  | 110  | 111  | 68                       | 68   | 69   | 70   | 70   | 71   | 72   |
|               | 95th                  | 108                      | 109  | 110  | 111  | 113  | 114  | 115  | 72                       | 72   | 73   | 74   | 74   | 75   | 76   |
|               | 99th                  | 115                      | 116  | 117  | 119  | 120  | 121  | 122  | 80                       | 80   | 80   | 81   | 82   | 83   | 83   |
| 7             | 50th                  | 93                       | 93   | 95   | 96   | 97   | 99   | 99   | 55                       | 56   | 56   | 57   | 58   | 58   | 59   |
|               | 90th                  | 106                      | 107  | 108  | 109  | 111  | 112  | 113  | 69                       | 70   | 70   | 71   | 72   | 72   | 73   |
|               | 95th                  | 110                      | 111  | 112  | 113  | 115  | 116  | 116  | 73                       | 74   | 74   | 75   | 76   | 76   | 77   |
|               | 99th                  | 117                      | 118  | 119  | 120  | 122  | 123  | 124  | 81                       | 81   | 82   | 82   | 83   | 84   | 84   |
| 8             | 50th                  | 95                       | 95   | 96   | 98   | 99   | 100  | 101  | 57                       | 57   | 57   | 58   | 59   | 60   | 60   |
|               | 90th                  | 108                      | 109  | 110  | 111  | 113  | 114  | 114  | 71                       | 71   | 71   | 72   | 73   | 74   | 74   |
|               | 95th                  | 112                      | 112  | 114  | 115  | 116  | 118  | 118  | 75                       | 75   | 75   | 76   | 77   | 78   | 78   |
|               | 99th                  | 119                      | 120  | 121  | 122  | 123  | 125  | 125  | 82                       | 82   | 83   | 83   | 84   | 85   | 86   |
| 9             | 50th                  | 96                       | 97   | 98   | 100  | 101  | 102  | 103  | 58                       | 58   | 58   | 59   | 60   | 61   | 61   |
|               | 90th                  | 110                      | 110  | 112  | 113  | 114  | 116  | 116  | 72                       | 72   | 72   | 73   | 74   | 75   | 75   |
|               | 95th                  | 114                      | 114  | 115  | 117  | 118  | 119  | 120  | 76                       | 76   | 76   | 77   | 78   | 79   | 79   |
|               | 99th                  | 121                      | 121  | 123  | 124  | 125  | 127  | 127  | 83                       | 83   | 84   | 84   | 85   | 86   | 87   |
| 10            | 50th                  | 98                       | 99   | 100  | 102  | 103  | 104  | 105  | 59                       | 59   | 59   | 60   | 61   | 62   | 62   |
|               | 90th                  | 112                      | 112  | 114  | 115  | 116  | 118  | 118  | 73                       | 73   | 73   | 74   | 75   | 76   | 76   |
|               | 95th                  | 116                      | 116  | 117  | 119  | 120  | 121  | 122  | 77                       | 77   | 77   | 78   | 79   | 80   | 80   |
|               | 99th                  | 123                      | 123  | 125  | 126  | 127  | 129  | 129  | 84                       | 84   | 85   | 86   | 86   | 87   | 88   |

## Blood Pressure Levels for Girls by Age and Height Percentile (Continued)

| Age<br>(Year) | BP<br>Percentile<br>↓ | Systolic BP (mmHg)       |      |      |      |      |      |      | Diastolic BP (mmHg)      |      |      |      |      |      |      |
|---------------|-----------------------|--------------------------|------|------|------|------|------|------|--------------------------|------|------|------|------|------|------|
|               |                       | ← Percentile of Height → |      |      |      |      |      |      | ← Percentile of Height → |      |      |      |      |      |      |
|               |                       | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th | 5th                      | 10th | 25th | 50th | 75th | 90th | 95th |
| 11            | 50th                  | 100                      | 101  | 102  | 103  | 105  | 106  | 107  | 60                       | 60   | 60   | 61   | 62   | 63   | 63   |
|               | 90th                  | 114                      | 114  | 116  | 117  | 118  | 119  | 120  | 74                       | 74   | 74   | 75   | 76   | 77   | 77   |
|               | 95th                  | 118                      | 118  | 119  | 121  | 122  | 123  | 124  | 78                       | 78   | 78   | 79   | 80   | 81   | 81   |
|               | 99th                  | 125                      | 125  | 126  | 128  | 129  | 130  | 131  | 85                       | 85   | 86   | 87   | 87   | 88   | 89   |
| 12            | 50th                  | 102                      | 103  | 104  | 105  | 107  | 108  | 109  | 61                       | 61   | 61   | 62   | 63   | 64   | 64   |
|               | 90th                  | 116                      | 116  | 117  | 119  | 120  | 121  | 122  | 75                       | 75   | 75   | 76   | 77   | 78   | 78   |
|               | 95th                  | 119                      | 120  | 121  | 123  | 124  | 125  | 126  | 79                       | 79   | 79   | 80   | 81   | 82   | 82   |
|               | 99th                  | 127                      | 127  | 128  | 130  | 131  | 132  | 133  | 86                       | 86   | 87   | 88   | 88   | 89   | 90   |
| 13            | 50th                  | 104                      | 105  | 106  | 107  | 109  | 110  | 110  | 62                       | 62   | 62   | 63   | 64   | 65   | 65   |
|               | 90th                  | 117                      | 118  | 119  | 121  | 122  | 123  | 124  | 76                       | 76   | 76   | 77   | 78   | 79   | 79   |
|               | 95th                  | 121                      | 122  | 123  | 124  | 126  | 127  | 128  | 80                       | 80   | 80   | 81   | 82   | 83   | 83   |
|               | 99th                  | 128                      | 129  | 130  | 132  | 133  | 134  | 135  | 87                       | 87   | 88   | 89   | 89   | 90   | 91   |
| 14            | 50th                  | 106                      | 106  | 107  | 109  | 110  | 111  | 112  | 63                       | 63   | 63   | 64   | 65   | 66   | 66   |
|               | 90th                  | 119                      | 120  | 121  | 122  | 124  | 125  | 125  | 77                       | 77   | 77   | 78   | 79   | 80   | 80   |
|               | 95th                  | 123                      | 123  | 125  | 126  | 127  | 129  | 129  | 81                       | 81   | 81   | 82   | 83   | 84   | 84   |
|               | 99th                  | 130                      | 131  | 132  | 133  | 135  | 136  | 136  | 88                       | 88   | 89   | 90   | 90   | 91   | 92   |
| 15            | 50th                  | 107                      | 108  | 109  | 110  | 111  | 113  | 113  | 64                       | 64   | 64   | 65   | 66   | 67   | 67   |
|               | 90th                  | 120                      | 121  | 122  | 123  | 125  | 126  | 127  | 78                       | 78   | 78   | 79   | 80   | 81   | 81   |
|               | 95th                  | 124                      | 125  | 126  | 127  | 129  | 130  | 131  | 82                       | 82   | 82   | 83   | 84   | 85   | 85   |
|               | 99th                  | 131                      | 132  | 133  | 134  | 136  | 137  | 138  | 89                       | 89   | 90   | 91   | 91   | 92   | 93   |
| 16            | 50th                  | 108                      | 108  | 110  | 111  | 112  | 114  | 114  | 64                       | 64   | 65   | 66   | 66   | 67   | 68   |
|               | 90th                  | 121                      | 122  | 123  | 124  | 126  | 127  | 128  | 78                       | 78   | 79   | 80   | 81   | 81   | 82   |
|               | 95th                  | 125                      | 126  | 127  | 128  | 130  | 131  | 132  | 82                       | 82   | 83   | 84   | 85   | 85   | 86   |
|               | 99th                  | 132                      | 133  | 134  | 135  | 137  | 138  | 139  | 90                       | 90   | 90   | 91   | 92   | 93   | 93   |
| 17            | 50th                  | 108                      | 109  | 110  | 111  | 113  | 114  | 115  | 64                       | 65   | 65   | 66   | 67   | 67   | 68   |
|               | 90th                  | 122                      | 122  | 123  | 125  | 126  | 127  | 128  | 78                       | 79   | 79   | 80   | 81   | 81   | 82   |
|               | 95th                  | 125                      | 126  | 127  | 129  | 130  | 131  | 132  | 82                       | 83   | 83   | 84   | 85   | 85   | 86   |
|               | 99th                  | 133                      | 133  | 134  | 136  | 137  | 138  | 139  | 90                       | 90   | 91   | 91   | 92   | 93   | 93   |

BP, blood pressure

\* The 90th percentile is 1.28 SD, 95th percentile is 1.645 SD, and the 99th percentile is 2.326 SD over the mean.

For research purposes, the standard deviations in Appendix Table B-1 allow one to compute BP Z-scores and percentiles for girls with height percentiles given in Table 4 (i.e., the 5th, 10th, 25th, 50th, 75th, 90th, and 95th percentiles). These height percentiles must be converted to height Z-scores given by (5% = -1.645; 10% = -1.28; 25% = -0.68; 50% = 0; 75% = 0.68; 90% = 1.28%; 95% = 1.645) and then computed according to the methodology in steps 2-4 described in Appendix B. For children with height percentiles other than these, follow steps 1-4 as described in Appendix B.

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