# Child stuntedness

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## Abstract

*The present work aims to show data on child stuntedness at the same time as it presents a way of trying to use machine learning prediction and techniques to give conditions to doctors and families to prevent this early way of disease.*

## 1. Stunting

### 1.1. Definition

According to [**?**], "Growth stunting is defined by comparing measurements of children's heights to the NCHS[1] growth reference population: children who fall below the fifth percentile of the reference population in height for age are defined as stunted, regardless of the reason for their shortness. As an indicator of nutritional status, comparison of children's measurements with growth reference curves may be used differently for populations of children than for individual children. The fact that an individual child falls below the fifth percentile for height for age on a growth reference curve may reflect normal variation in growth within a population: the individual child may be short simply because both his parents were short and not because of inadequate nutrition. However, if substantially more than $5\%$ of an identified child population have height for age that is less than the fifth percentile on the reference curve, then the population is said to have a higher-than-expected prevalence of stunting, and inadequate nutrition is generally the first cause considered."

### 1.2. Causes

Inadequate nutrition is just one of several causes of growth stunting. Other contributors to stunting include chronic or recurrent infections, sometimes in combination with intestinal parasites. The prevalence of growth stunting, particularly among children under two years of age, can also reflect the prevalence of low birth weight in a population. Finally, in rare cases, growth stunting may reflect extreme psychosocial stress without nutritional deficiencies.

The contributions of each of these causes to the growth stunting prevalence rate are only partly understood. One study concluded that from $20\%$ to $40\%$ of the prevalence of growth stunting in the first two years of life can be attributed to low birth weight. However, inadequate nutrition may still be implicated because some low weight births may be due to maternal nutritional deficiencies during pregnancy.

Just as low birth weight and nutritional deficiencies are interrelated, so also are inadequate nutrition and the chronic or recurrent infections that are believed to contribute to growth stunting. There is evidence that even mild nutritional deficits can alter the immune response in children, before clinical signs of malnutrition occur, and that nutritional deficiencies during pregnancy can impair the infant's immune response after birth. Thus, the reasons for any given child's growth impairment may be complex. However, inadequate nutrition is a common theme that suggests a key focus for a policy response to the problem of growth stunting.

### 1.3. Consequences

Children who suffer from growth retardation as a result of poor diets or recurrent infections tend to be at greater risk for illness and death. Stunting is the result of long-term nutritional deprivation and often results in delayed mental development, poor school performance and reduced intellectual capacity. This in turn affects economic productivity at national level. Women of short stature are at greater risk for obstetric complications because of a smaller pelvis. Small women are at greater risk of delivering an infant with low birth weight, contributing to the intergenerational cycle of malnutrition, as infants of low birth weight or retarded intrauterine growth tend be smaller as adults.

### 1.4. Measuring stunting

Several important age-related differences and discontinuities in the reference growth curves are used to measure stunting. First, for children less than $24$ months of age,

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[1] National Center for Health Statistics

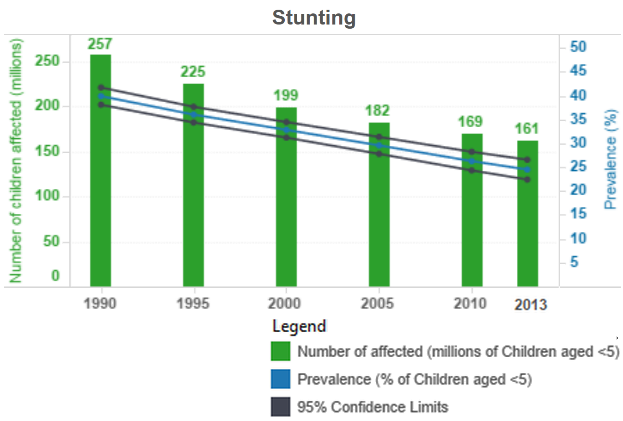


Figure 1. Child malnutriotion trend for stunting (According to [?]).

growth is determined by measuring the length of a recumbent child. After 24 months, growth is determined by measuring the height of a standing child. Because length and height measurements are not equivalent, there is a natural discontinuity between growth curves for children below and above 24 months of age.

The WHO[2] uses to classify stunting as height for age $< -2$ SD[3] of the WHO Child Growth Standards median (measurement charts of girls and boys are at the end of this document).

## 2. Problem statement

Using the statement described in [?], we have the goal to determine a combination of early measures that would be a good predictor for birth weight. In pursuit of this goal, we have collected time series data from ultrasounds on pregnant mothers. We would like you to use this data to predict a child's birth weight and birth date (days from pregnancy start).

For each fetus given sex, status, and multiple ultrasound measurements(columns 5-12) during the pregnancy (time being the variable t.ultsnd). The data from the repeated ultrasounds provides a small time series that can be used for predicting the birth weight and day.

For each prediction $(b_i, w_i)$, the error from the true birth date and birth weight will be measured as the squared Mahalanobis distance,

$$e_i = (b_i - b_{0i}, w_i - w_{0i})^T S^{-1} (b_i - b_{0i}, w_i - w_{0i})' \quad (1)$$

where $S^{-1}$ is the inverse of the sample covariance matrix calculated on the complete dataset.

The Mahalanobis distance is a measure of the distance between a point $P$ and a distribution $D$, introduced by P. C. Mahalanobis in 1936[?]. It is a multi-dimensional generalization of the idea of measuring how many standard deviations away $P$ is from the mean of $D$. This distance is zero if $P$ is at the mean of $D$, and grows as $P$ moves away from the mean: Along each principal component axis, it measures the number of standard deviations from $P$ to the mean of $D$. If each of these axes is rescaled to have unit variance, then Mahalanobis distance corresponds to standard Euclidean distance in the transformed space. Mahalanobis distance is thus unitless and scale-invariant, and takes into account the correlations of the data set.

$$S^{-1} = \begin{pmatrix} 3554.42 & -328.119 \\ -328.119 & 133.511 \end{pmatrix} \quad (2)$$

Scores will be calculated as a generalized $R^2$ measure of fit. This is calculated as follows. The total sum of errors for the submission will be calculated as $SSE = \sum(e_i)$.

A baseline sum of squared error will be calculated by predicting the sample means for each fetus, that is the mean values of b and w for the current training set,

$$e_{0i} = (\bar{b} - b_{0i}, \bar{w} - w_{0i}) S^{-1} (\bar{b} - b_{0i}, \bar{w} - w_{0i})' \quad (3)$$

$$SSE_0 = \sum(e_{0i})$$

## 3. Development: numbers, results and dificulties

The dataset given in [?] is composed by 5651 rows, with 14 columns each row, as shown in **??**.

There were lines referencing the measurement of only one child but in different times and different values that must be considered and some data entries did not have enough records to evaluate with the $R$ script. In this case, we must to remove these spurious data.

After a clean, we divide the dataset in training, testing and validation in the proportion $80 : 16 : 4$ respectively, to be confident in the final results.

The answer is not only a variable, but a vector with components. These kind of problems are more complicated than problems involving only a variable response.

Some of the attributes are time series. We had to decide how to deal with it. Decide to stay with average and is an example; decide to work with the series implies having to think about how to include a number as an attribute, which is not trivial.

Using the scripts we reached the value of $SSE = 62643.36994767563$.

We didn't try another algorithms as kNN or random forest, for instance. During evaluation, the value of $Odv3$ respect to weight and the last measurement time for the birth date were important features.

[2] World Health Organization
[3] standard deviations

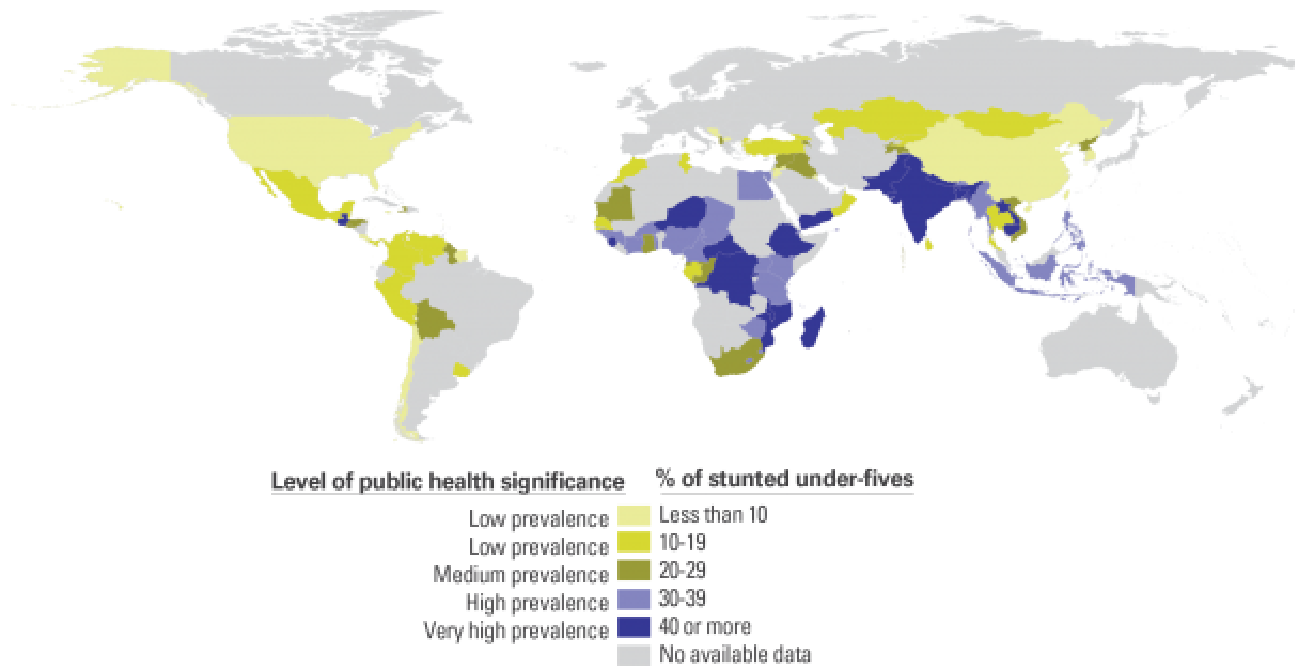



Figure 2. Undernutrition contributes to half of all deaths in children under 5 and is widespread in Asia and Africa Percentage of under-five children who are stunted, 2008 - 2013).

| Column | Variable | Type | Label/Description |
|---|---|---|---|
| 1 | Id | int | Unique Fetus ID |
| 2 | t.ultsnd | float | Estimated fetus gestational age from last menstrual recall date |
| 3 | Sex | int | 0 = Male, 1 = Female |
| 4 | Status | int | Maternal nutritional status (1 or 2) |
| 5-12 | Odv | float | Dependent variables: Ultrasound observed measurements |
| 13 | Birth Sz | float | Birth Weight ($w$) |
| 14 | Duration | float | Pregnancy Duration, or Birthday ($b$) |

Table 1. Dataset definition (from [**?**])

## 4. Further studies

There's a lot of ways to understand the problem of stunting in child populations. The website Topcoder[4] recently released another two problems regarding this issue [5].

Some ways of understand of how to deal this problem permeates the ethnic differences, for instance.

This work clearly does not contain all the possibilities and variations that may occur in relation to the subject of malnutrition and stunting. The possibilities of dealing with this subject are diverse, so we propose the extrapolation to this discipline and continue the development of intelligent algorithms that can be in support of medical decisions to inform pregnant women about the nutrition of their children.

For this problem, we are dealing with the issue of health information from children from the mother's womb. Thus, although the final result within a machine learning system is a set of numbers from a practical way, it is actually helping doctors and / or families, analyzing the results and evaluating the need to take actions to revert the malnutrition.

Thus, the ultimate goal is eventually to create a model that can help make decisions about whether to take action to reverse a possible framework for future child malnutrition, to the extent that we are evaluating the child from the womb breast.

Use another kind of predictors (as kNN, Random forest) can bring new ways to evaluate the data.

[4] https://www.topcoder.com/

[5] http://community.topcoder.com/longcontest/?module=ViewProblemStatement&rd=16153&pm=13478 and https://www.topcoder.com/longcontest/?module=ViewProblemStatement&rd=16209&compid=45332

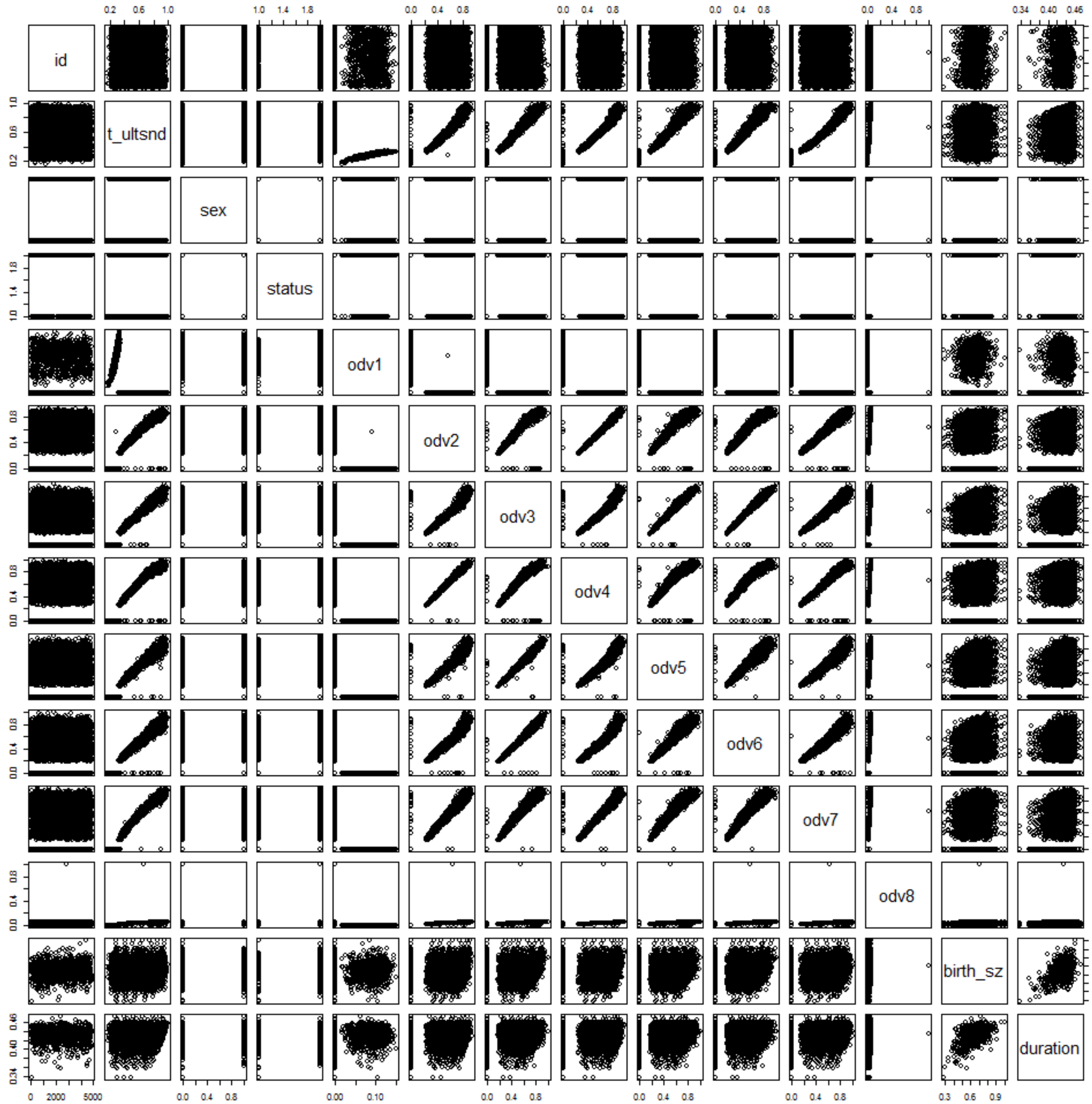



Figure 4. The whole dataset plotted.

The data is a few messy and in some times don't make sense. The enunciation isn't clearly. And there is another challenges at topcoder sites with respect this issues with more features and maybe more interesting to evaluate according Machine Learning.

## 5. Charts and Tables

The charts below are from CDC[6] website and given the default curves of growth for girls and boys from the birth to 24 months. This is helpful because using by parent's they can evaluate the children growth according medicine measurement.

[6]Center for Disease Control and Prevention

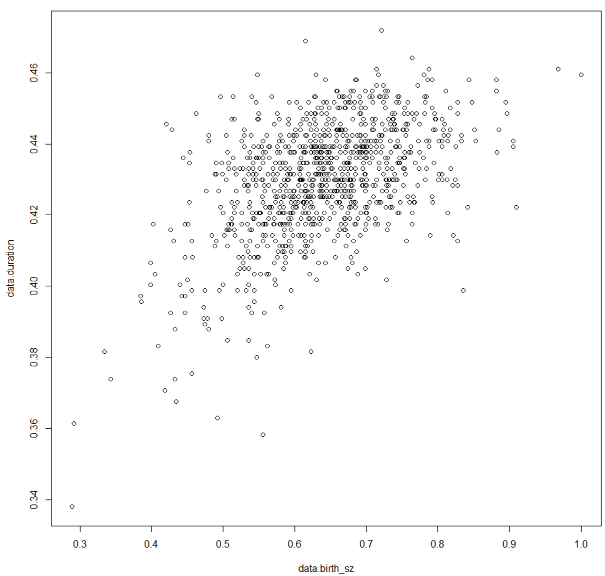
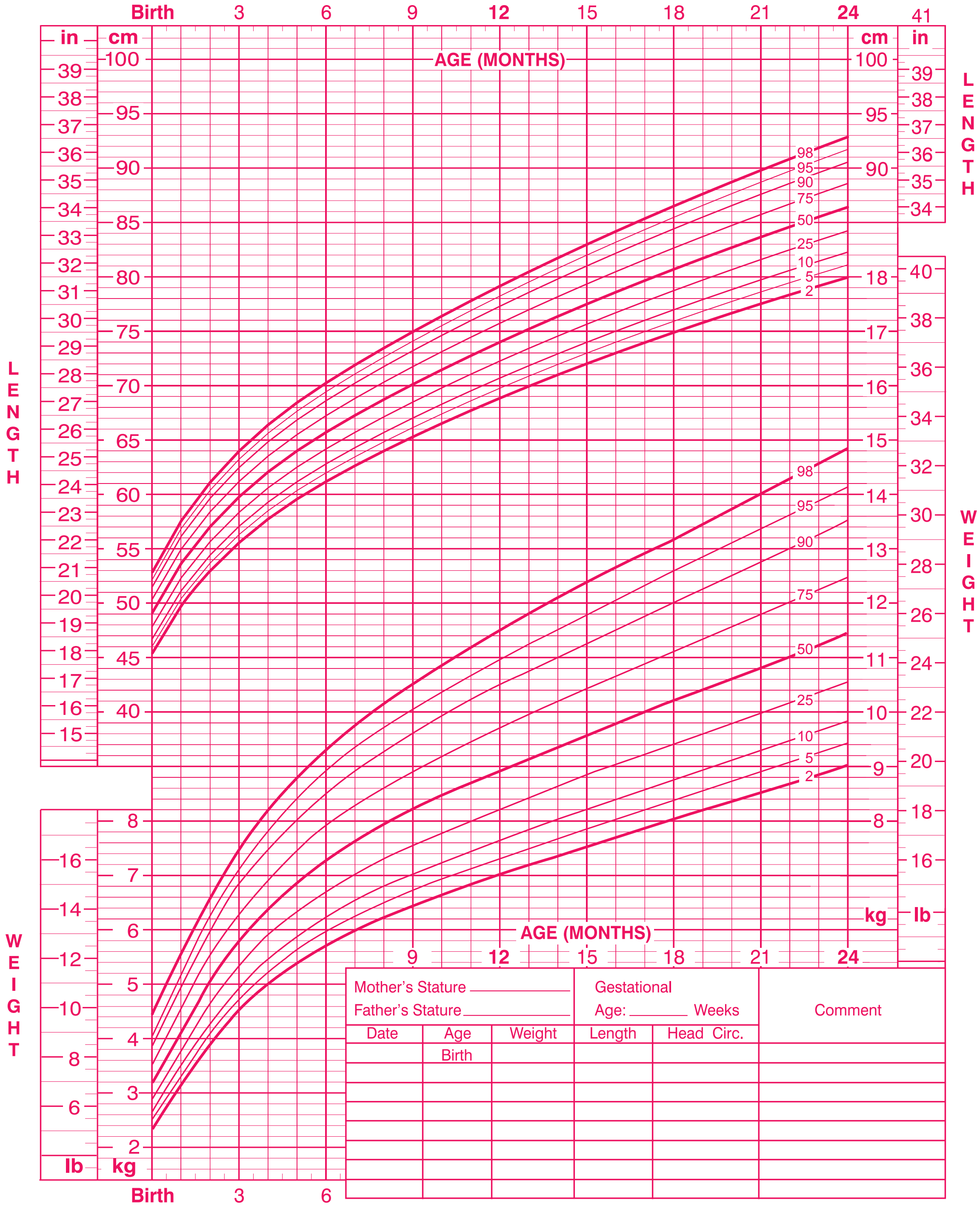



Figure 3. Birth vs Duration plot according the dataset.

# Birth to 24 months: Girls
# Length-for-age and Weight-for-age percentiles

NAME ______________________

RECORD # ______________________




Mother's Stature ______________

Father's Stature ______________

Gestational Age: ________ Weeks

| Date | Age | Weight | Length | Head Circ. | Comment |
|---|---|---|---|---|---|
| | Birth | | | | |
| | | | | | |
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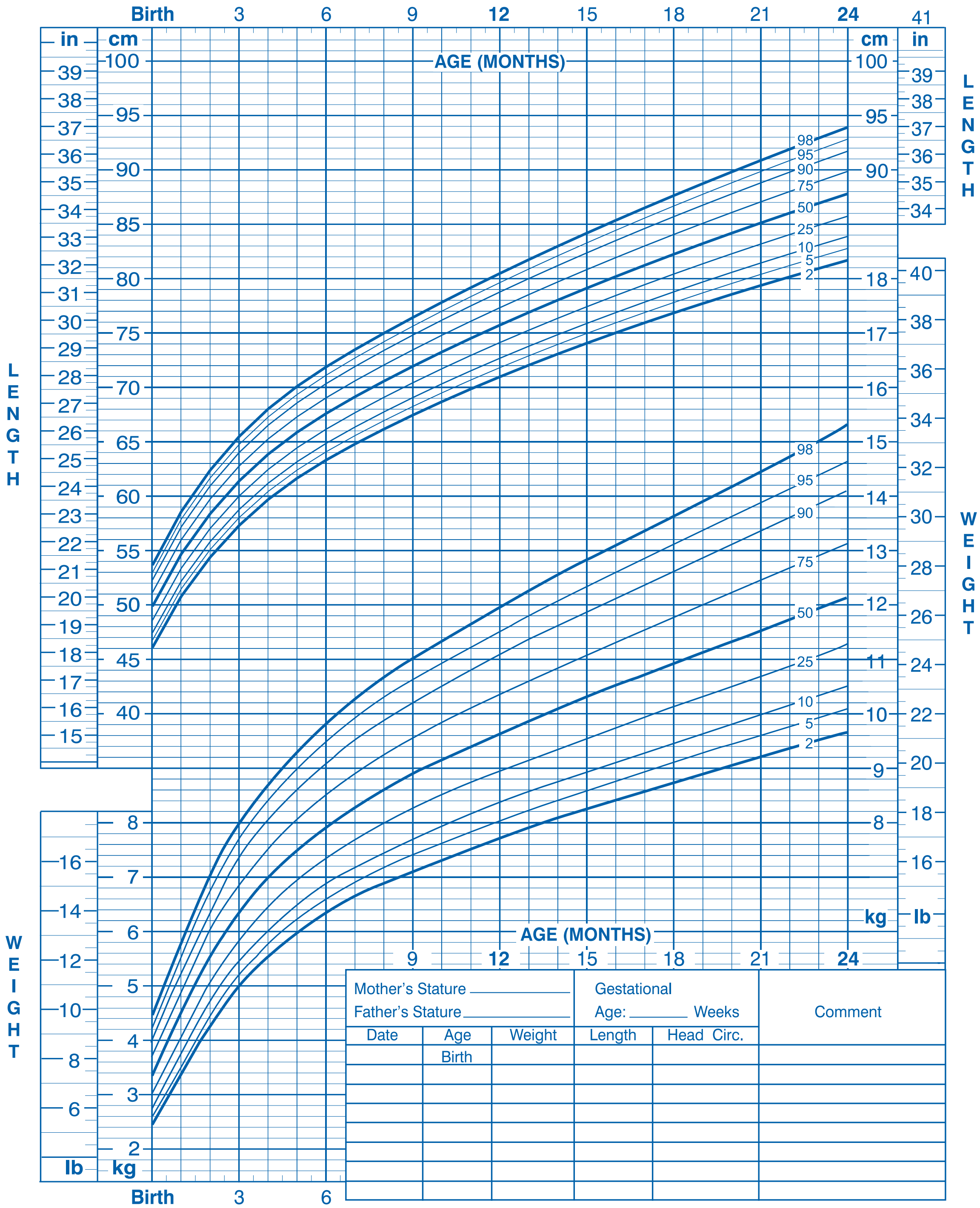
Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

## Birth to 24 months: Boys
## Length-for-age and Weight-for-age percentiles

NAME ______________________

RECORD # ______________




| Mother's Stature ______ Father's Stature ______ | | | Gestational Age: ______ Weeks | | Comment |
|---|---|---|---|---|---|
| Date | Age | Weight | Length | Head Circ. | |
| | Birth | | | | |
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Published by the Centers for Disease Control and Prevention, November 1, 2009
SOURCE: WHO Child Growth Standards (http://www.who.int/childgrowth/en)

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| Age (in months) | 3rd Percentile (cm) | 5th Percentile (cm) | 10th Percentile (cm) | 25th Percentile (cm) | 50th Percentile (cm) | 75th Percentile (cm) | 90th Percentile (cm) | 95th Percentile (cm) | 97th Percentile (cm) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 44.9251 | 45.56841 | 46.55429 | 48.18937 | 49.98888 | 51.77126 | 53.36153 | 54.30721 | 54.919 |
| 0.5 | 47.97812 | 48.55809 | 49.4578 | 50.97919 | 52.69598 | 54.44054 | 56.03444 | 56.99908 | 57.62984 |
| 1.5 | 52.19859 | 52.72611 | 53.55365 | 54.9791 | 56.62843 | 58.35059 | 59.9664 | 60.96465 | 61.62591 |
| 2.5 | 55.26322 | 55.77345 | 56.57772 | 57.9744 | 59.60895 | 61.33788 | 62.98158 | 64.00789 | 64.69241 |
| 3.5 | 57.73049 | 58.23744 | 59.0383 | 60.43433 | 62.077 | 63.82543 | 65.49858 | 66.54889 | 67.2519 |
| 4.5 | 59.82569 | 60.33647 | 61.1441 | 62.55409 | 64.21686 | 65.99131 | 67.69405 | 68.76538 | 69.48354 |
| 5.5 | 61.66384 | 62.18261 | 63.00296 | 64.43546 | 66.12531 | 67.92935 | 69.66122 | 70.75128 | 71.48218 |
| 6.5 | 63.31224 | 63.84166 | 64.67854 | 66.13896 | 67.86018 | 69.69579 | 71.45609 | 72.56307 | 73.30488 |
| 7.5 | 64.81395 | 65.35584 | 66.21181 | 67.70375 | 69.45908 | 71.32735 | 73.11525 | 74.23767 | 74.98899 |
| 8.5 | 66.19833 | 66.75398 | 67.63088 | 69.15682 | 70.94804 | 72.84947 | 74.6641 | 75.80074 | 76.56047 |
| 9.5 | 67.48635 | 68.05675 | 68.95591 | 70.51761 | 72.34586 | 74.2806 | 76.1211 | 77.27095 | 78.03819 |
| 10.5 | 68.6936 | 69.27949 | 70.20192 | 71.80065 | 73.66665 | 75.63462 | 77.50016 | 78.66234 | 79.43637 |
| 11.5 | 69.832 | 70.43397 | 71.38046 | 73.01712 | 74.9213 | 76.92224 | 78.81202 | 79.98578 | 80.76602 |
| 12.5 | 70.91088 | 71.52941 | 72.50055 | 74.17581 | 76.11838 | 78.15196 | 80.0652 | 81.2499 | 82.03585 |
| 13.5 | 71.9377 | 72.57318 | 73.56946 | 75.2838 | 77.2648 | 79.33061 | 81.2666 | 82.46167 | 83.25292 |
| 14.5 | 72.91853 | 73.5713 | 74.59309 | 76.34685 | 78.36622 | 80.4638 | 82.42185 | 83.6268 | 84.42302 |
| 15.5 | 73.85839 | 74.52871 | 75.57634 | 77.36973 | 79.42734 | 81.5562 | 83.53568 | 84.75006 | 85.55095 |
| 16.5 | 74.76147 | 75.44958 | 76.5233 | 78.35646 | 80.45209 | 82.61174 | 84.61204 | 85.83547 | 86.64078 |
| 17.5 | 75.63132 | 76.33742 | 77.43742 | 79.31042 | 81.44384 | 83.63377 | 85.65431 | 86.88645 | 87.69597 |
| 18.5 | 76.47096 | 77.19523 | 78.32168 | 80.23453 | 82.40544 | 84.62515 | 86.66541 | 87.90595 | 88.7195 |
| 19.5 | 77.283 | 78.0256 | 79.17863 | 81.13131 | 83.33938 | 85.58837 | 87.64786 | 88.89652 | 89.71393 |
| 20.5 | 78.06971 | 78.83077 | 80.01048 | 82.00292 | 84.24783 | 86.52562 | 88.60385 | 89.86038 | 90.68153 |
| 21.5 | 78.83308 | 79.61271 | 80.81919 | 82.85129 | 85.1327 | 87.43879 | 89.53533 | 90.79951 | 91.62428 |
| 22.5 | 79.57485 | 80.37315 | 81.60646 | 83.67811 | 85.99565 | 88.32957 | 90.44402 | 91.71563 | 92.54392 |
| 23.5 | 80.29656 | 81.11363 | 82.37381 | 84.48487 | 86.83818 | 89.19948 | 91.33143 | 92.61031 | 93.44203 |
| 24.5 | 80.99959 | 81.83552 | 83.12259 | 85.2729 | 87.66161 | 90.04985 | 92.19893 | 93.48491 | 94.31998 |
| 25.5 | 81.74464 | 82.58135 | 83.87245 | 86.03703 | 88.45247 | 90.8787 | 93.07143 | 94.38775 | 95.24419 |
| 26.5 | 82.47365 | 83.31105 | 84.60576 | 86.78329 | 89.22326 | 91.68468 | 93.91817 | 95.263 | 96.13962 |
| 27.5 | 83.18812 | 84.02609 | 85.32399 | 87.51317 | 89.97549 | 92.46929 | 94.74064 | 96.1121 | 97.00763 |
| 28.5 | 83.88931 | 84.72769 | 86.02833 | 88.22788 | 90.71041 | 93.23385 | 95.54016 | 96.93639 | 97.84957 |
| 29.5 | 84.57826 | 85.41688 | 86.71978 | 88.9284 | 91.42908 | 93.97951 | 96.318 | 97.73717 | 98.66677 |
| 30.5 | 85.25589 | 86.09452 | 87.39917 | 89.6156 | 92.13242 | 94.70732 | 97.07531 | 98.51569 | 99.46052 |
| 31.5 | 85.92294 | 86.76134 | 88.06723 | 90.2902 | 92.82127 | 95.41824 | 97.81324 | 99.27318 | 100.2321 |
| 32.5 | 86.58009 | 87.41799 | 88.72457 | 90.95287 | 93.49638 | 96.11319 | 98.53287 | 100.0109 | 100.9829 |
| 33.5 | 87.22791 | 88.06503 | 89.37177 | 91.60421 | 94.15847 | 96.79307 | 99.23531 | 100.73 | 101.7142 |
| 34.5 | 87.86696 | 88.70301 | 90.00937 | 92.24482 | 94.80823 | 97.45873 | 99.92162 | 101.4318 | 102.4274 |
| 35.5 | 88.49774 | 89.33242 | 90.63786 | 92.87525 | 95.44637 | 98.11108 | 100.5929 | 102.1174 | 103.1237 |

Table 2. Males, Ages Birth - 36 Months

| Age (in months) | 3rd Percentile (cm) | 5th Percentile (cm) | 10th Percentile (cm) | 25th Percentile (cm) | 50th Percentile (cm) | 75th Percentile (cm) | 90th Percentile (cm) | 95th Percentile (cm) | 97th Percentile (cm) |
|---|---|---|---|---|---|---|---|---|---|
| 0 | 45.09488 | 45.57561 | 46.33934 | 47.68345 | 49.2864 | 51.0187 | 52.7025 | 53.77291 | 54.49527 |
| 0.5 | 47.46916 | 47.96324 | 48.74248 | 50.09686 | 51.68358 | 53.36362 | 54.96222 | 55.96094 | 56.62728 |
| 1.5 | 50.95701 | 51.47996 | 52.29627 | 53.69078 | 55.28613 | 56.93136 | 58.45612 | 59.38911 | 60.00338 |
| 2.5 | 53.62925 | 54.17907 | 55.03144 | 56.47125 | 58.09382 | 59.74045 | 61.24306 | 62.15166 | 62.74547 |
| 3.5 | 55.8594 | 56.43335 | 57.31892 | 58.80346 | 60.45981 | 62.1233 | 63.62648 | 64.52875 | 65.11577 |
| 4.5 | 57.8047 | 58.40032 | 59.31633 | 60.84386 | 62.5367 | 64.22507 | 65.74096 | 66.64653 | 67.23398 |
| 5.5 | 59.54799 | 60.16323 | 61.10726 | 62.6759 | 64.40633 | 66.12418 | 67.65995 | 68.57452 | 69.16668 |
| 6.5 | 61.13893 | 61.77208 | 62.7421 | 64.35005 | 66.11842 | 67.8685 | 69.42868 | 70.35587 | 70.95545 |
| 7.5 | 62.60993 | 63.25958 | 64.25389 | 65.89952 | 67.70574 | 69.48975 | 71.07731 | 72.01952 | 72.62835 |
| 8.5 | 63.98348 | 64.64845 | 65.66559 | 67.34745 | 69.19124 | 71.01019 | 72.62711 | 73.58601 | 74.20532 |
| 9.5 | 65.2759 | 65.9552 | 66.99394 | 68.7107 | 70.59164 | 72.44614 | 74.09378 | 75.0705 | 75.70118 |
| 10.5 | 66.49948 | 67.19226 | 68.25154 | 70.00202 | 71.91962 | 73.80997 | 75.48923 | 76.4846 | 77.12729 |
| 11.5 | 67.66371 | 68.36925 | 69.44814 | 71.23128 | 73.18501 | 75.11133 | 76.82282 | 77.83742 | 78.49257 |
| 12.5 | 68.77613 | 69.4938 | 70.59149 | 72.40633 | 74.39564 | 76.35791 | 78.10202 | 79.13625 | 79.80419 |
| 13.5 | 69.8428 | 70.57207 | 71.68784 | 73.53349 | 75.55785 | 77.55594 | 79.3329 | 80.38705 | 81.06801 |
| 14.5 | 70.86874 | 71.60911 | 72.74233 | 74.61799 | 76.67686 | 78.71058 | 80.5205 | 81.59475 | 82.28891 |
| 15.5 | 71.85807 | 72.60914 | 73.75924 | 75.66416 | 77.75701 | 79.82613 | 81.66903 | 82.7635 | 83.47098 |
| 16.5 | 72.81433 | 73.57571 | 74.74217 | 76.67568 | 78.80198 | 80.90623 | 82.78208 | 83.89683 | 84.6177 |
| 17.5 | 73.74047 | 74.51184 | 75.6942 | 77.65565 | 79.81492 | 81.95399 | 83.86269 | 84.99774 | 85.73205 |
| 18.5 | 74.63908 | 75.42012 | 76.61797 | 78.60678 | 80.79852 | 82.97211 | 84.91353 | 86.06887 | 86.81663 |
| 19.5 | 75.51237 | 76.30282 | 77.51576 | 79.53138 | 81.75512 | 83.96292 | 85.93689 | 87.11249 | 87.8737 |
| 20.5 | 76.36229 | 77.16191 | 78.38958 | 80.4315 | 82.68679 | 84.92846 | 86.93481 | 88.13061 | 88.90526 |
| 21.5 | 77.19056 | 77.9991 | 79.2412 | 81.30893 | 83.59532 | 85.87054 | 87.90908 | 89.125 | 89.91305 |
| 22.5 | 77.99868 | 78.81595 | 80.07216 | 82.16525 | 84.48233 | 86.79077 | 88.86127 | 90.09723 | 90.89866 |
| 23.5 | 78.78801 | 79.61381 | 80.88385 | 83.00187 | 85.34924 | 87.69056 | 89.79282 | 91.04873 | 91.86347 |
| 24.5 | 79.55974 | 80.39391 | 81.67752 | 83.82007 | 86.19732 | 88.57121 | 90.70499 | 91.98074 | 92.80876 |
| 25.5 | 80.33998 | 81.18804 | 82.49318 | 84.67209 | 87.09026 | 89.50562 | 91.67718 | 92.97574 | 93.81864 |
| 26.5 | 81.11332 | 81.97223 | 83.29459 | 85.5036 | 87.95714 | 90.40982 | 92.61658 | 93.93693 | 94.79426 |
| 27.5 | 81.87334 | 82.74084 | 84.07717 | 86.31151 | 88.79602 | 91.28258 | 93.52227 | 94.86339 | 95.73464 |
| 28.5 | 82.61506 | 83.48951 | 84.83741 | 87.09346 | 89.60551 | 92.12313 | 94.39371 | 95.75464 | 96.63928 |
| 29.5 | 83.33473 | 84.21496 | 85.57273 | 87.84783 | 90.38477 | 92.93113 | 95.23082 | 96.61061 | 97.50808 |
| 30.5 | 84.02972 | 84.91494 | 86.28139 | 88.57362 | 91.13342 | 93.70662 | 96.03385 | 97.43164 | 98.34139 |
| 31.5 | 84.69837 | 85.58809 | 86.96242 | 89.27042 | 91.85154 | 94.45005 | 96.80343 | 98.2184 | 99.13993 |
| 32.5 | 85.33987 | 86.23379 | 87.6155 | 89.93835 | 92.53964 | 95.16218 | 97.54052 | 98.97193 | 99.90473 |
| 33.5 | 85.95413 | 86.85208 | 88.24089 | 90.57795 | 93.19854 | 95.84411 | 98.24636 | 99.69353 | 100.6372 |
| 34.5 | 86.54167 | 87.44359 | 88.83932 | 91.1902 | 93.82945 | 96.49721 | 98.92246 | 100.3848 | 101.3388 |
| 35.5 | 87.10349 | 88.00937 | 89.41196 | 91.77639 | 94.43382 | 97.12307 | 99.57056 | 101.0475 | 102.0116 |

Table 3. Females, Ages Birth - 36 Months

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