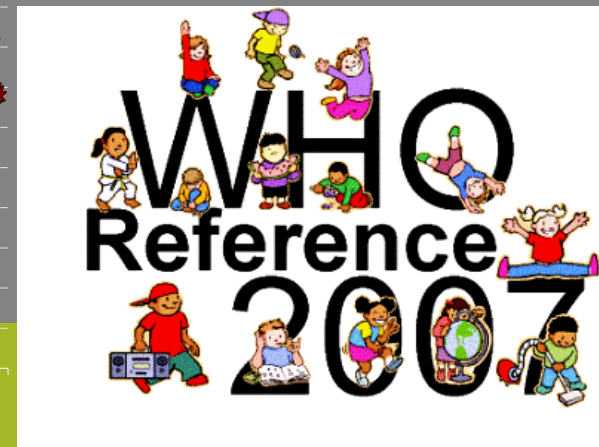
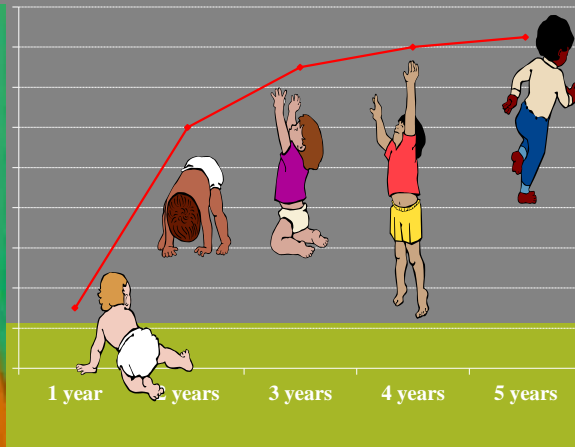
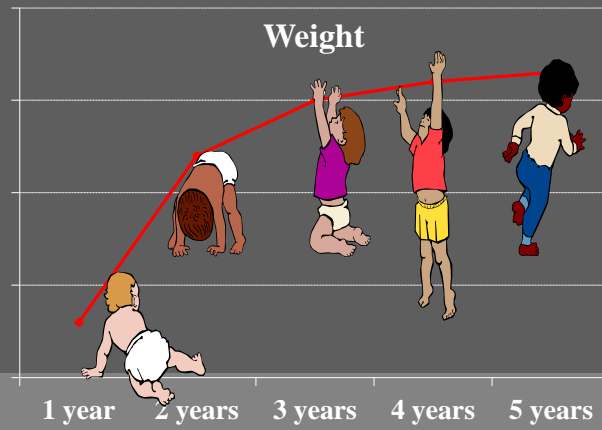


# MONITORING HUMAN GROWTH FROM THE WOMB TO ADULTHOOD



**Dr Leila Cheikh Ismail**

INTERGROWTH-21<sup>st</sup> Project Leader  
Nuffield Department of Obstetrics and Gynaecology  
Women's Centre, John Radcliffe Hospital  
University of Oxford  
Oxford, UK



# WHO CHILD GROWTH STANDARDS

## Background and Global Overview

WHY?

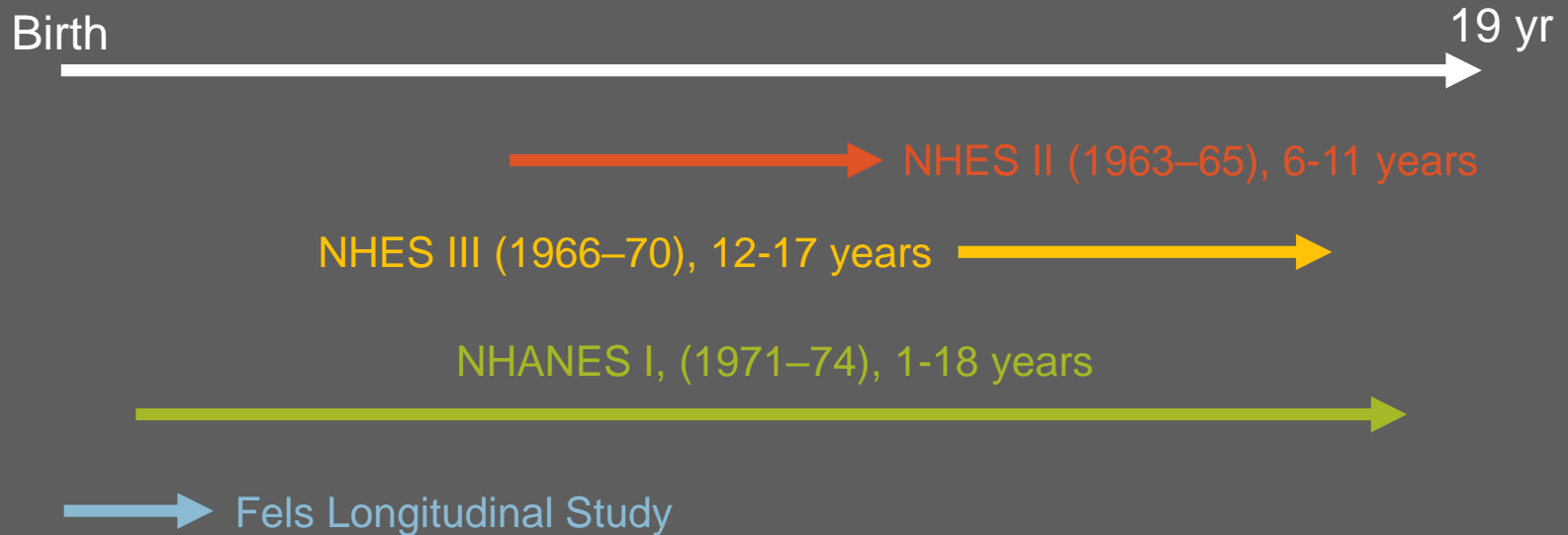
# RATIONALE

Prior to 2006, WHO recommended the use of the growth references developed by the United States National Center for Health Statistics (NCHS) of the CDC, based on national survey data collected in the 1960s and 1970s.

- WHO growth references, the NCHS/WHO growth references, or the NCHS/WHO growth chart
- Included growth charts for infants from birth to 36 months and for older children from 2 to 18 years of age

# NCHS/WHO GROWTH CHART

## SAMPLE ORIGINS



This reference was based on data from **several unrelated samples** of children from a **single country** and suffered from a number of **technical and biological drawbacks** that made it inadequate to monitor early childhood growth.

# CONCEPTUAL LIMITATIONS

# WHO 1995 RECOMMENDATIONS

- Data from multiple countries and geographic regions (including less-developed countries)
- Data should reflect the status of healthy populations with unconstrained growth (even when not representative of the whole population)
- Data for children from birth to adolescence should be included
- Sample size and data-collection procedures should be appropriate and well documented



# NCHS/WHO GROWTH CHART LIMITATIONS

- Data from multiple countries and geographic regions (including less-developed countries)
- NCHS/WHO growth chart were derived from samples from **one country**: the United States

# NCHS/WHO GROWTH CHART LIMITATIONS

- Data should reflect the status of healthy populations with unconstrained growth (even when not representative of the whole population)

→ Sample selection used a **descriptive** approach, which when applied to a population like that of the United States, which has an increasing prevalence of obesity, was likely to result in a **non-healthy sample**.

# NCHS/WHO GROWTH CHART LIMITATIONS

- Data should reflect the status of healthy populations with unconstrained growth (even when not representative of the whole population)

→ Data collected may not reflect the **desirable eating and growth patterns** for these age groups or the more **recent patterns** worldwide.

For example, the Fels dataset reflects the growth of **formula-fed** rather than breastfed infants.

# NCHS/WHO GROWTH CHART LIMITATIONS

- Sample size and data-collection procedures should be appropriate

→ For most sex and age groups in the NCHS/WHO references, the sample size was **approximately 120.**

# WHO RECOMMENDATION (1995)

Human growth worldwide should be  
evaluated using  
international standards describing  
how individuals should grow

# REFERENCES vs. STANDARDS

**Reference charts** describe how fetuses and newborns *have* grown at a particular time and/or place

**International standards** describe how fetuses and newborns *should* grow when nutritional, environmental and health constraints on growth are minimal

# REFERENCES vs. STANDARDS

**Reference charts** describe how fetuses and newborns *have* grown at a particular time and/or place

**International standards** describe how fetuses and newborns *should* grow when nutritional, environmental and health constraints on growth are minimal

# HOW?



# A GROWTH CURVE FOR THE 21<sup>ST</sup> CENTURY

## The WHO Multicentre Growth Reference Study

# MILESTONES IN THE DEVELOPMENT OF THE WHO CHILD GROWTH STANDARDS

## 1991-1993 WHO Working Group on Infant Growth

- Comprehensive review shows growth patterns of healthy breastfed infants differ from the current NCHS/WHO international reference
- A new growth reference is needed to improve infant health management

# MILESTONES IN THE DEVELOPMENT OF THE WHO CHILD GROWTH STANDARDS

## 1993 WHO Expert Committee

- Recommends development of a new international growth reference
- Based on an international sample of “healthy” infants

## 1994 WHA resolution (WHA 47.5)

- Endorses need for new reference
- Requests it to be based on breastfed infants

# WHO GROWTH REFERENCE STUDY

## Optimal Nutrition

- Breastfed infants
- Appropriate complementary feeding

## Optimal Environment

- No microbiological contamination
- No smoking

## Optimal Health Care

- Immunization
- Paediatric routines



**Optimal  
Growth**

# WHO CHILD GROWTH STANDARDS STUDY SAMPLE

Six countries where there are:

- <5% stunting, wasting, underweight
- At least 20% mothers breastfeeding
- No health/environmental constraints on growth

And where mothers are:

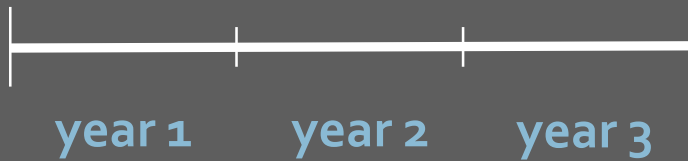
- Non-smoking
- Willing to follow feeding recommendations
- Single, term birth
- No significant morbidity

# WHO Multicentre Growth Reference Study (MGRS)



# MGRS STUDY DESIGN

## Longitudinal (0-24mo)



→ 1743 total enrolled  
(1542, 88.5% completed FUP)

## Cross-sectional (18-71mo)



→ 6669 (3450 boys/3219 girls)

The following links provide access to the first and second set of the WHO child growth standards (0-60 months):

:: [Length/height-for-age](#)

:: [Weight-for-age](#)

:: [Weight-for-length](#)

:: [Weight-for-height](#)

:: [BMI-for-age](#)

:: [Head circumference-for-age](#)

:: [Arm circumference-for-age](#)

:: [Subscapular skinfold-for-age](#)

:: [Triceps skinfold-for-age](#)

:: [Motor development milestones](#)



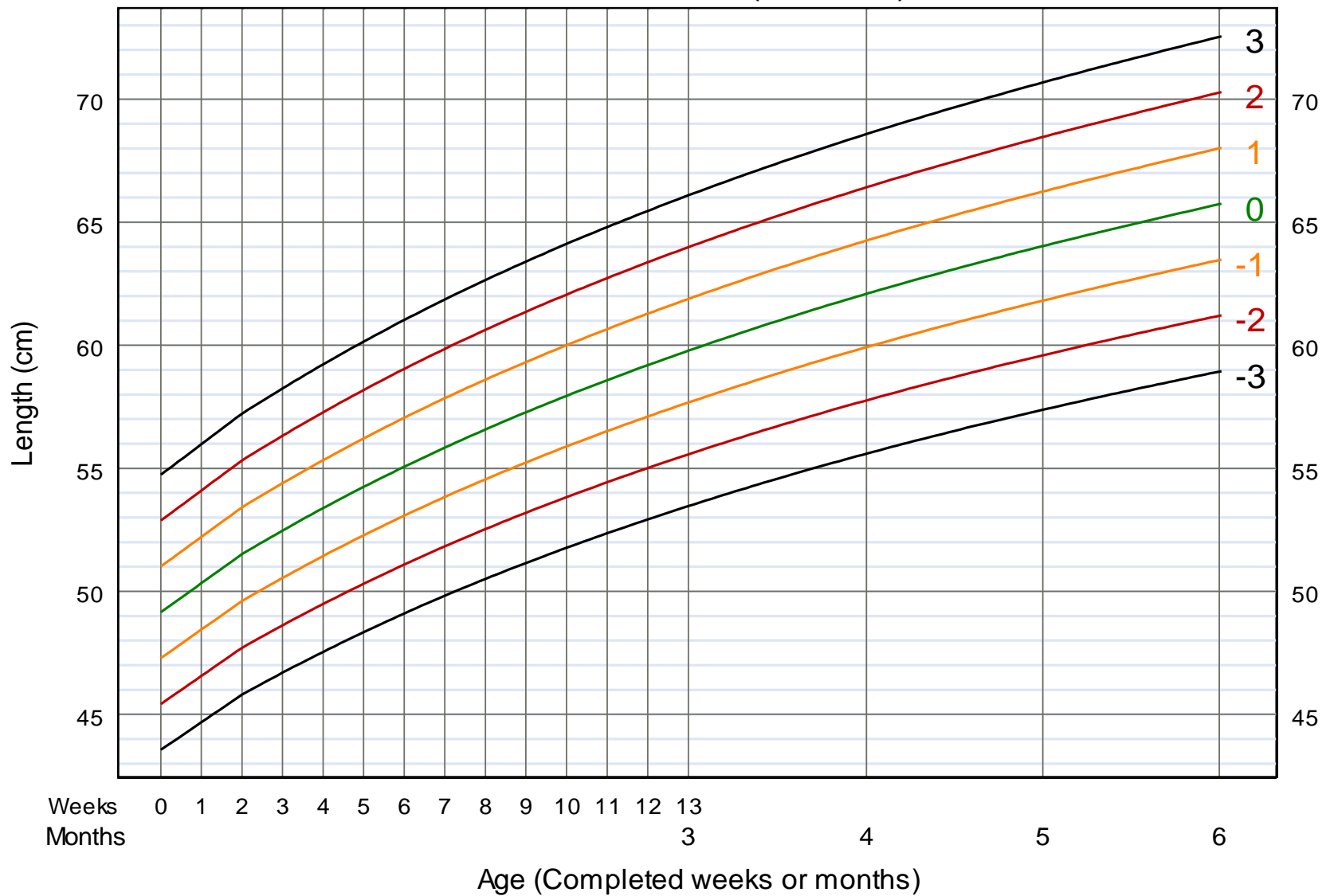
# LENGTH/HEIGHT-FOR-AGE

## Z-scores by gender

- Length-for-age: Birth to 6 months
- Length-for-age: Birth to 2 years
- Length-for-age: 6 months to 2 years
- Height-for-age: 2 to 5 years
- Length/height-for-age: Birth to 5 years

# Length-for-age GIRLS

## Birth to 6 months (z-scores)



# INTERPRET PLOTTED POINTS FOR GROWTH INDICATORS

- The curved lines printed on the growth charts will help you interpret the plotted points that represent a child's growth status. The line labeled 0 on each chart represents the **median**, which is, generally speaking, the average
- The other curved lines are **z-score lines** which indicate distance from the average
- Z-score lines on the growth charts are numbered **positively** (1, 2, 3) or **negatively** (-1, -2, -3). In general, a plotted point that is far from the median in either direction (for example, close to the 3 or -3 z-score line) may represent a **growth problem**, although other factors must be considered, such as the growth pattern, the health condition of the child and the height of the parents

# DEFINITION OF GROWTH PROBLEMS

Z-scores	Growth indicators			
	Length/height-for-age	Weight-for-age	Weight-for-length/height	BMI-for-age
Above 3	<i>See note 1</i>	<i>See note 2</i>	Obese	Obese
Above 2		<i>See note 2</i>	Overweight	Overweight
Above 1		<i>See note 2</i>	Possible risk of overweight <i>(see note 3)</i>	Possible risk of overweight <i>(see note 3)</i>
0 (median)				
Below 1				
Below 2	Stunted <i>(see note 4)</i>	Underweight	Wasted	Wasted
Below 3	Severely stunted <i>(see note 4)</i>	Severely underweight <i>(see note 5)</i>	Severely wasted	Severely wasted



# GROWTH REFERENCE DATA FOR 5-19 YEARS

## Background and Global Overview

# RATIONALE

- In 2006, the WHO released the new Child Growth Standards from birth to 5 years of age
- Need to harmonize growth assessment tools conceptually and pragmatically

# HISTORY

- In early 2006, a group of expert was tasked to evaluate the feasibility of developing a single international growth reference for school-aged children and adolescents.
- Several options were considered...

HOW?



# OPTION 1

A growth standard could be constructed for this age group by conducting a similar study to the one that led to the development of the WHO Child Growth Standards for 0 to 5 years.

→ It was agreed that such a study would not be feasible for older children, as it would not be possible to control the dynamics of their environment.

# OPTION 2

A growth reference could be constructed for this age group using existing historical data and discussed the criteria for selecting the data sets.

→ This approach was abandoned due to the great heterogeneity in methods and data quality, sample size, age categories, socioeconomic status of participating children and various other factors critical to growth curve construction.

# OPTION 3

To reconstruct the 1977 NCHS/WHO growth reference from 5 to 19 years, using the original sample (a non-obese sample with expected heights), supplemented with data from the WHO Child Growth Standards (to facilitate a smooth transition at 5 years), and applying the state-of-the-art statistical methods

→ WHO Growth reference 5-19 years

The links below provide access to the reference charts and tables by indicator:

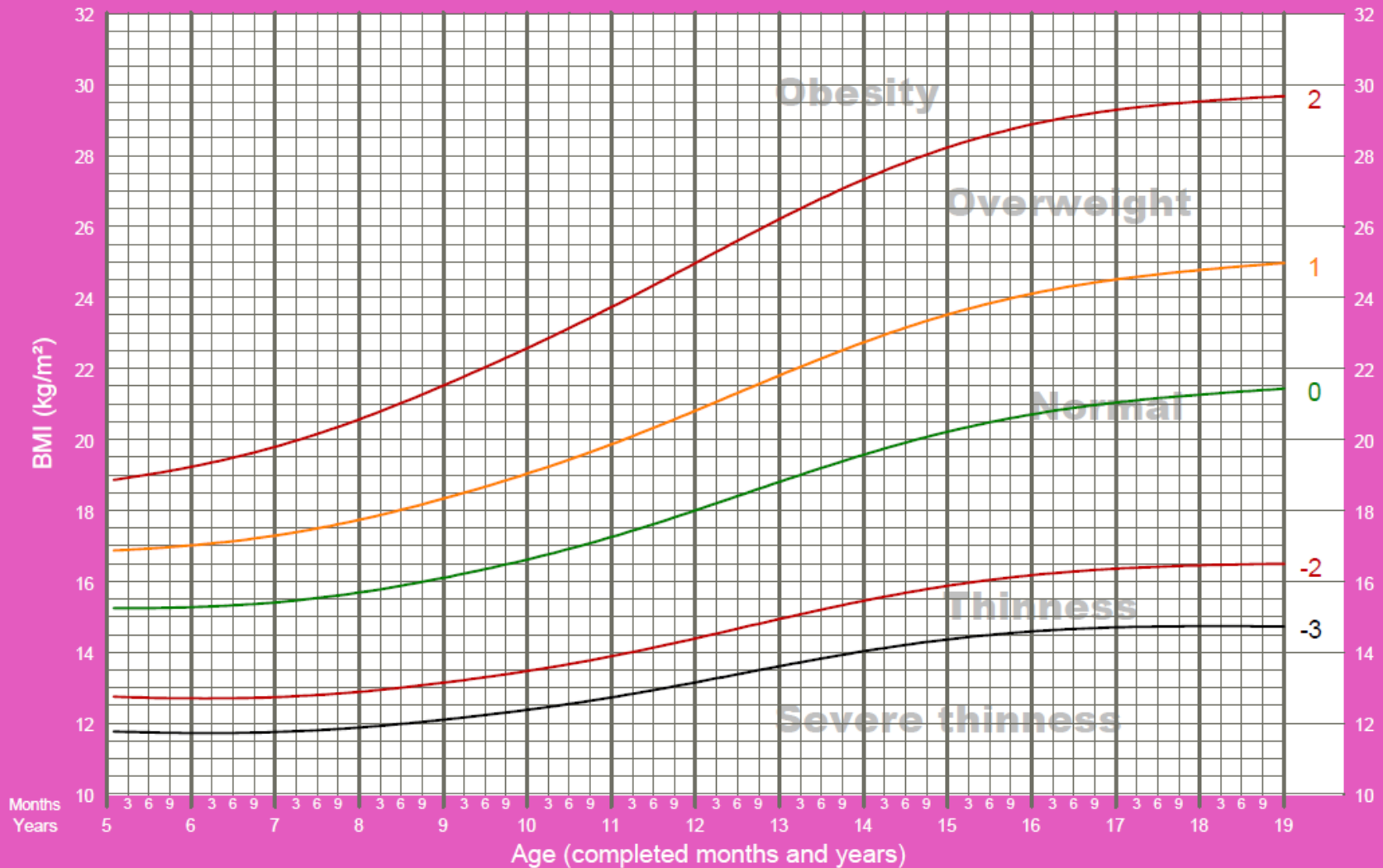
::: [BMI-for-age \(5-19 years\)](#)

::: [Height-for-age \(5-19 years\)](#)

::: [Weight-for-age \(5-10 years\)](#)

# BMI-for-age GIRLS

5 to 19 years (z-scores)



# WHO BMI-FOR-AGE (5-19 YEARS)

Cut-offs:

**Overweight:** above +1 Z-score

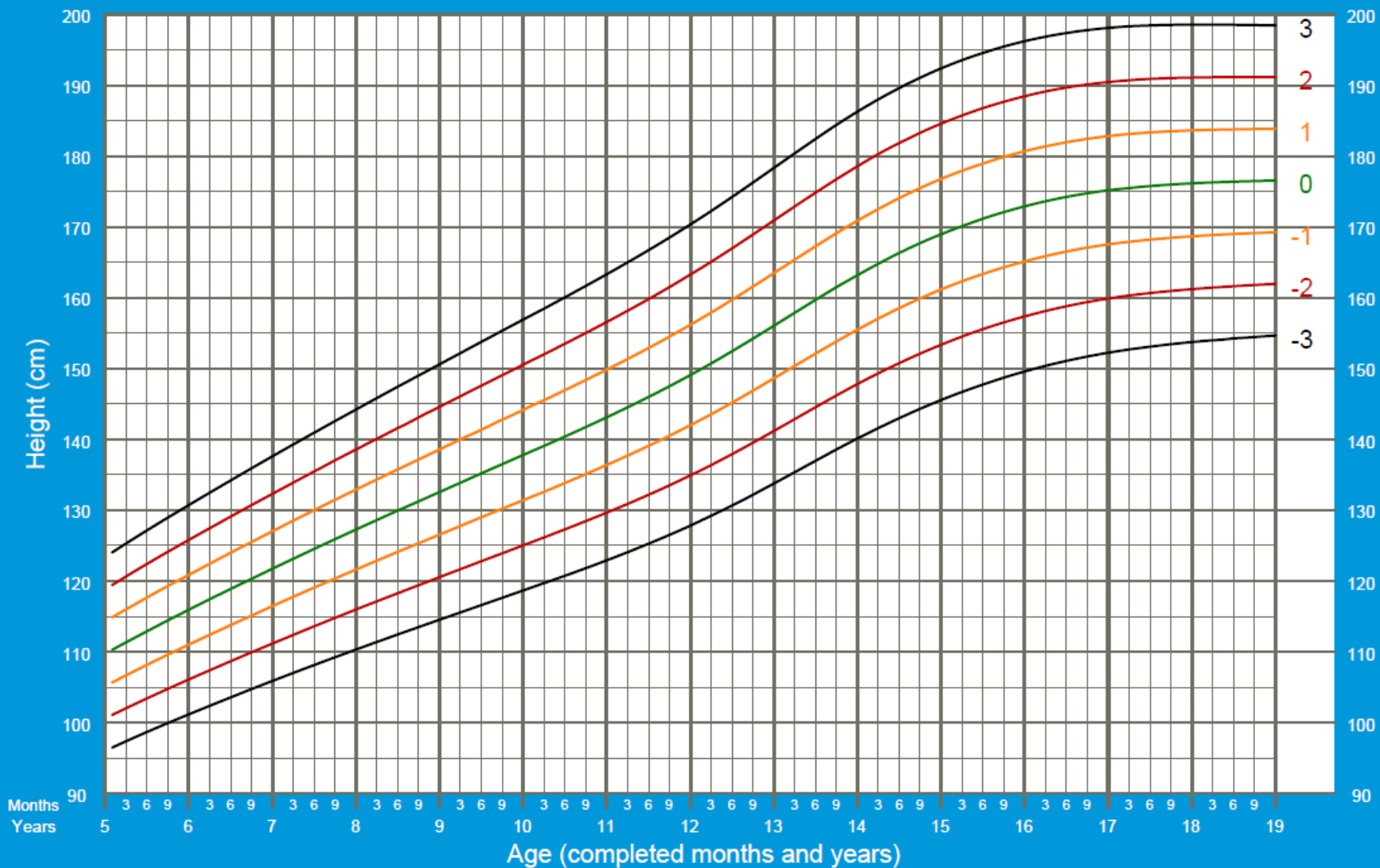
**Obesity:** above +2 Z-score

**Thinness:** below -2 Z-score

**Severe thinness:** below -3 Z-score

# Height-for-age BOYS

5 to 19 years (z-scores)



# WHO HEIGHT-FOR-AGE (5-19 YEARS)

Cut-offs:

**Above +3 Z-score:** Tallness is rarely a problem, unless it is so excessive that it may indicate an endocrine disorder.

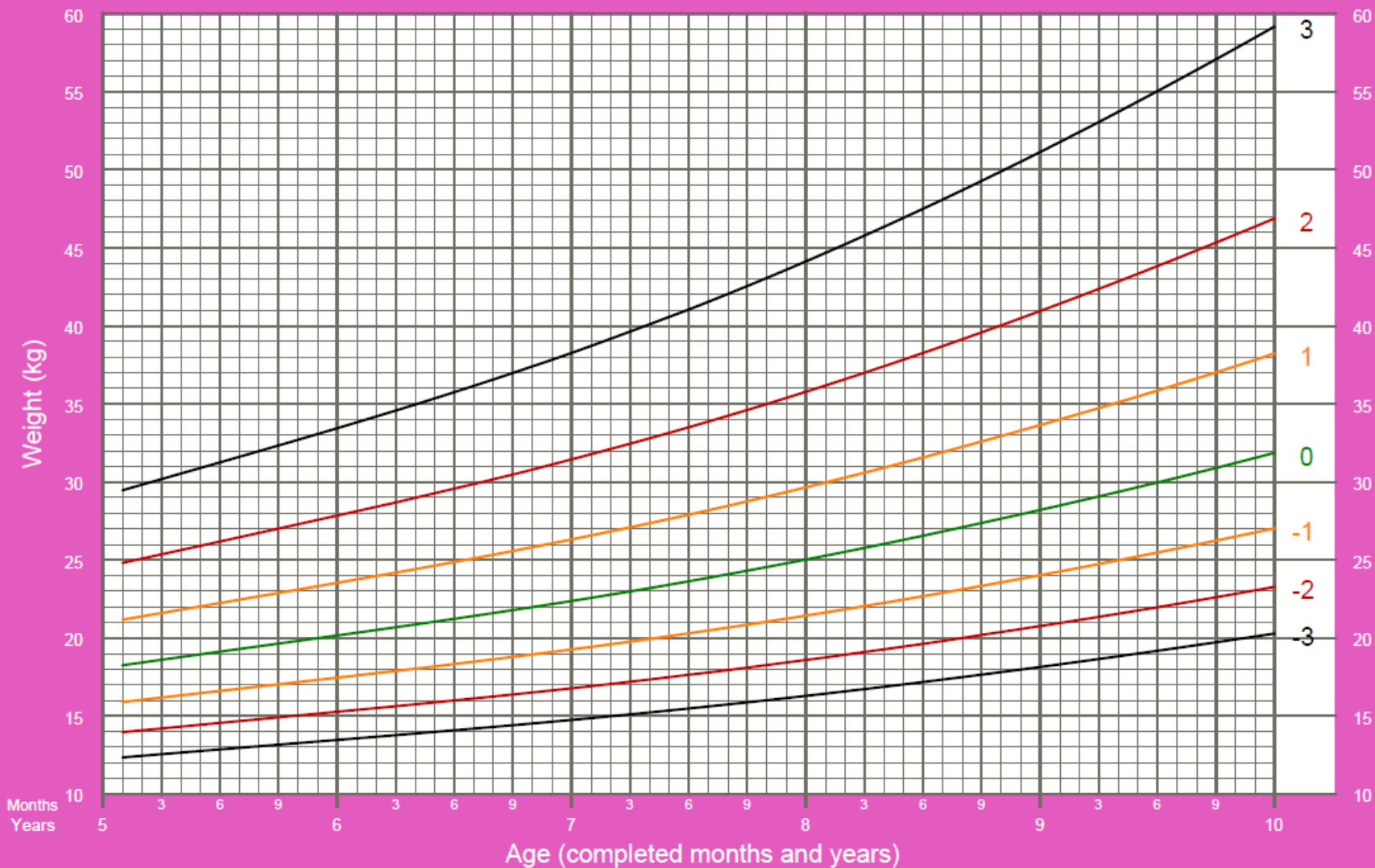
**Stunted:** below -2 Z-score

**Severely stunted:** below -3 Z-score



# Weight-for-age GIRLS

5 to 10 years (z-scores)



# WHO WEIGHT-FOR-AGE (5-10 YEARS)

Cut-offs:

Z-score  $> +1$ : A child whose weight-for-age falls in this range may have a growth problem, but this is better assessed from weight-for-length/height or BMI-for-age

**Underweight:** below  $-2$  Z-score

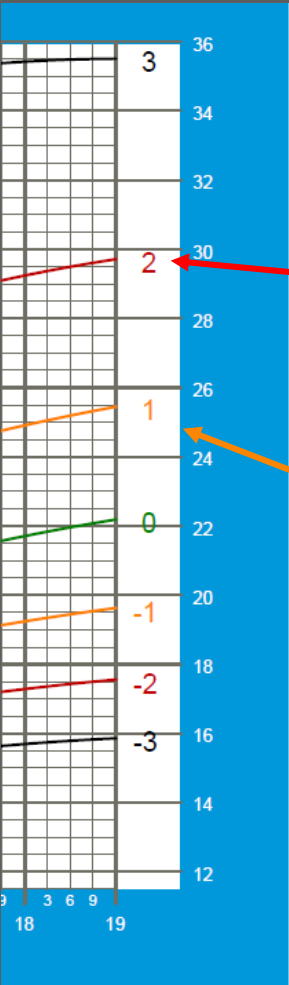
**Severely underweight:** below  $-3$  Z-score

# TRANSITION TO ADULT CUT-OFFS

In the 2007 BMI-for-age at 19 years of age:

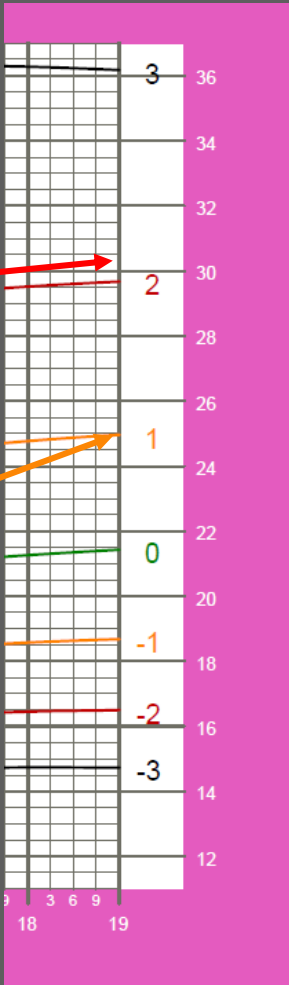
- +1 SD (25.4 kg/m<sup>2</sup> for boys and 25.0 kg/m<sup>2</sup> for girls) are equivalent to the overweight cut-off used for adults (> 25.0 kg/m<sup>2</sup>)
- +2 SD (29.7 kg/m<sup>2</sup> for both sexes) compares closely with the cut-off for obesity (> 30.0 kg/m<sup>2</sup>)

# TRANSITION TO ADULT CUT-OFFS



**Obesity**  
( $\geq 30 \text{ kg/m}^2$ )

**Overweight**  
( $\geq 25 \text{ kg/m}^2$ )





# INTERGROWTH-21<sup>ST</sup> STANDARDS AND REFERENCES

Background and Global Overview

WHY?

# RATIONALE

WHO child growth standards  
(0-60 months):

- Length/height-for-age
- Weight-for-age
- Weight-for-length/height
- BMI-for-age
- Head circumference-for-age
- Arm circumference-for-age
- Subscapular skinfold-for-age
- Triceps skinfold-for-age
- Motor development milestones



What is missing?



**No information on:**

- Growth during pregnancy
- Size at birth by GA
- Postnatal growth of preterm infants

# HOW?



# CHALLENGES

## Practical considerations:

Where? → Site selection

Who? → Population selection

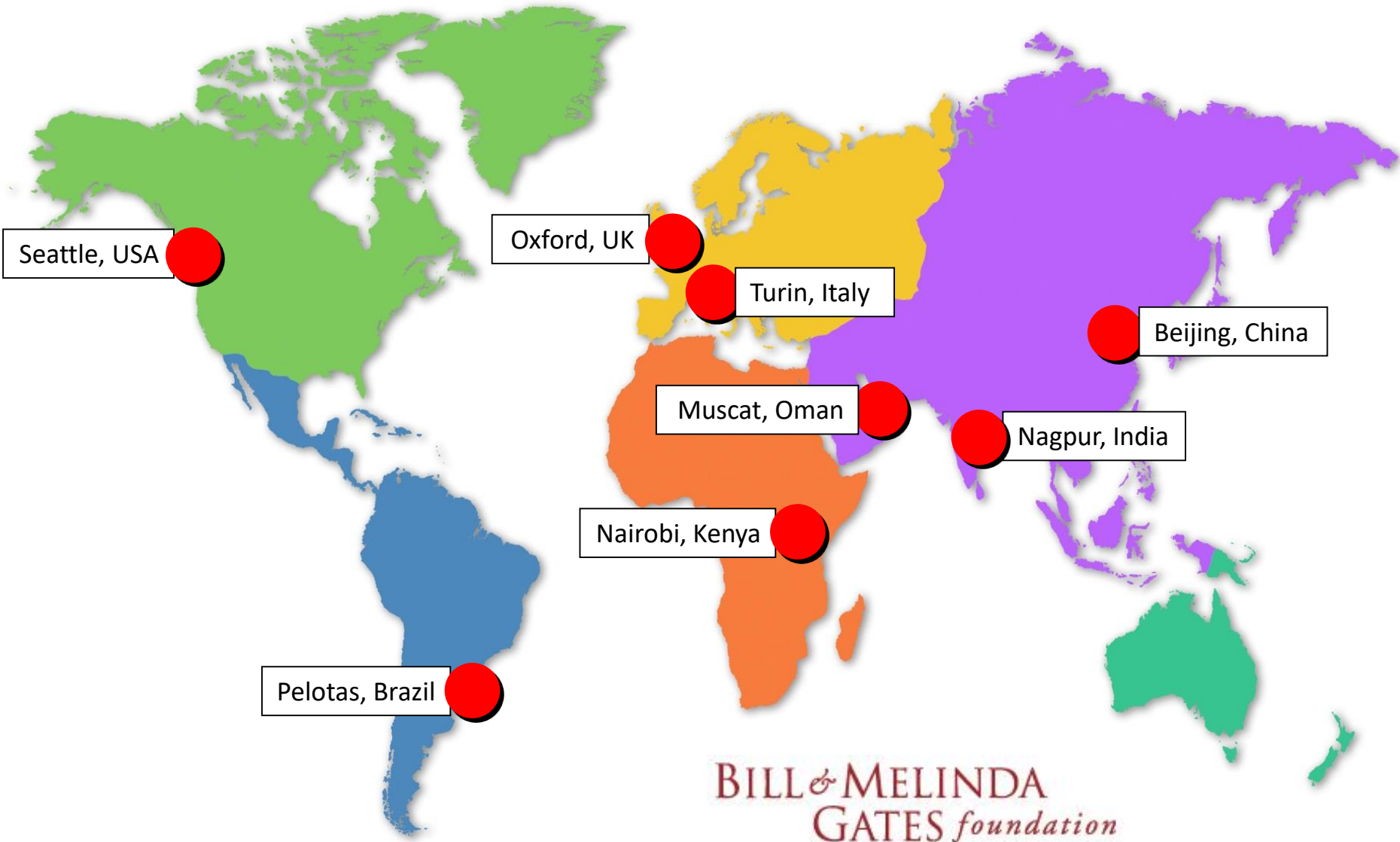
## Methodological considerations:

Multicentre study → Same equipment, protocols, level of care and recommendations

Complement WHO charts → Same anthropometric equipment and protocol

Pooling the results → Ensuring good data quality throughout the study and across sites

# INTERGROWTH-21<sup>ST</sup> SITES



# POPULATION SELECTION

## LOW-RISK PREGNANCY CRITERIA

- a) aged  $\geq 18$  and  $\leq 35$  years;
- b) BMI  $\geq 18.5$  and  $< 30$  kg/m<sup>2</sup>;
- c) height  $\geq 153$  cm;
- d) singleton pregnancy;
- e) a known LMP with regular cycles (defined as a 26-30 day cycle in the previous 3 months), without hormonal contraceptive use, pregnancy or breastfeeding in the 3 months before pregnancy;
- f) natural conception
- g) no relevant past medical history (refer to screening form), with no need for long-term medication (including fertility

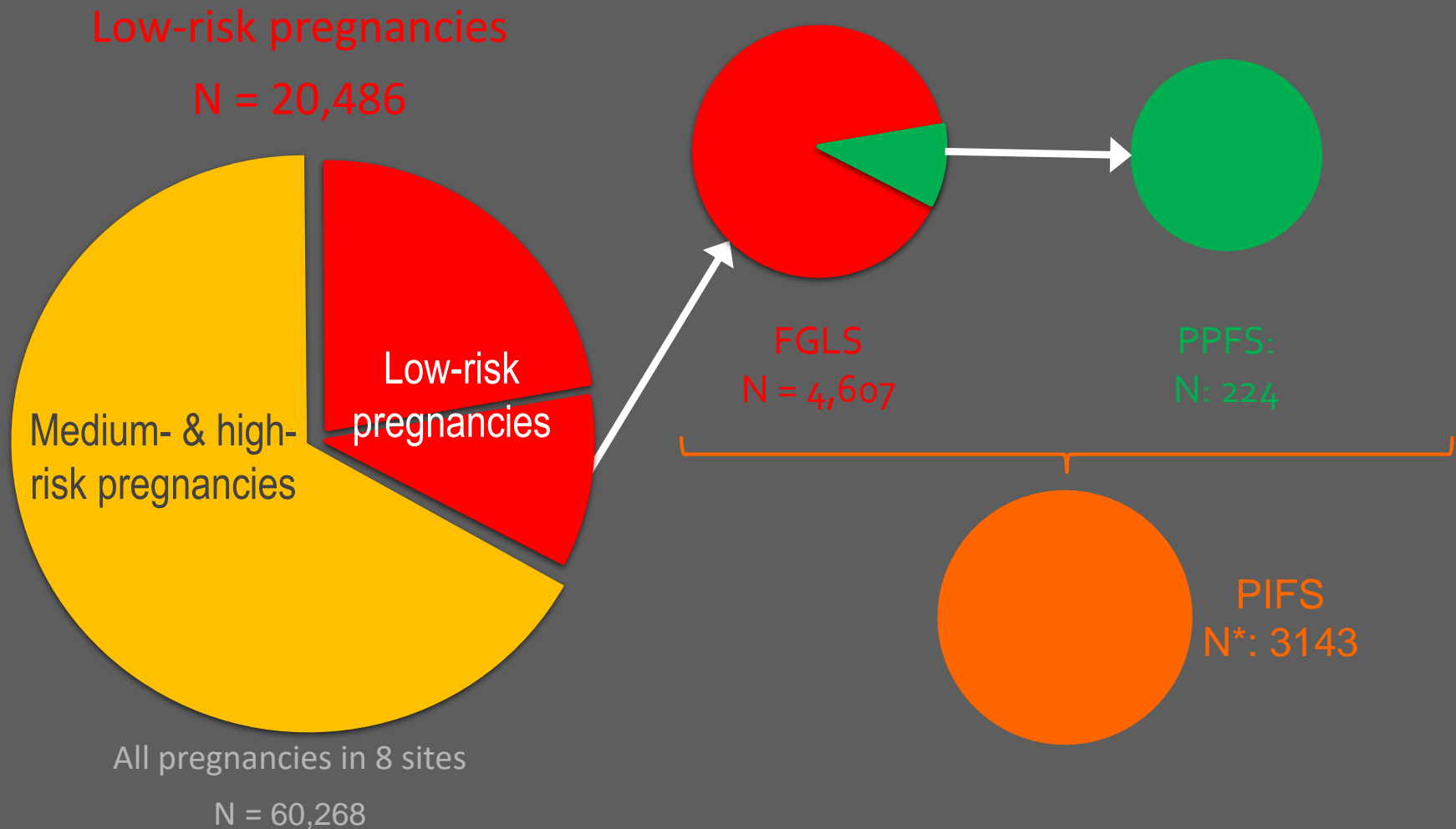
**Criteria defining a low-risk study population as healthy and well-nourished (both before and during pregnancy) to ensure that fetal growth is optimal**

- o) no clinically significant atypical red cell alloantibodies;
- p) negative urinalysis;
- q) systolic blood pressure  $< 140$  mmHg and diastolic blood pressure  $< 90$  mmHg;
- r) haemoglobin  $\geq 11$  g/dl;
- s) negative syphilis test and no clinical evidence of any other sexually transmitted diseases, including clinical Trichomoniasis;
- t) not in an occupation with risk of exposure to chemicals or toxic substances, or very physically demanding activity to be evaluated by local standards. Also women should not be conducting vigorous or contact sports, as well as scuba diving or similar activities

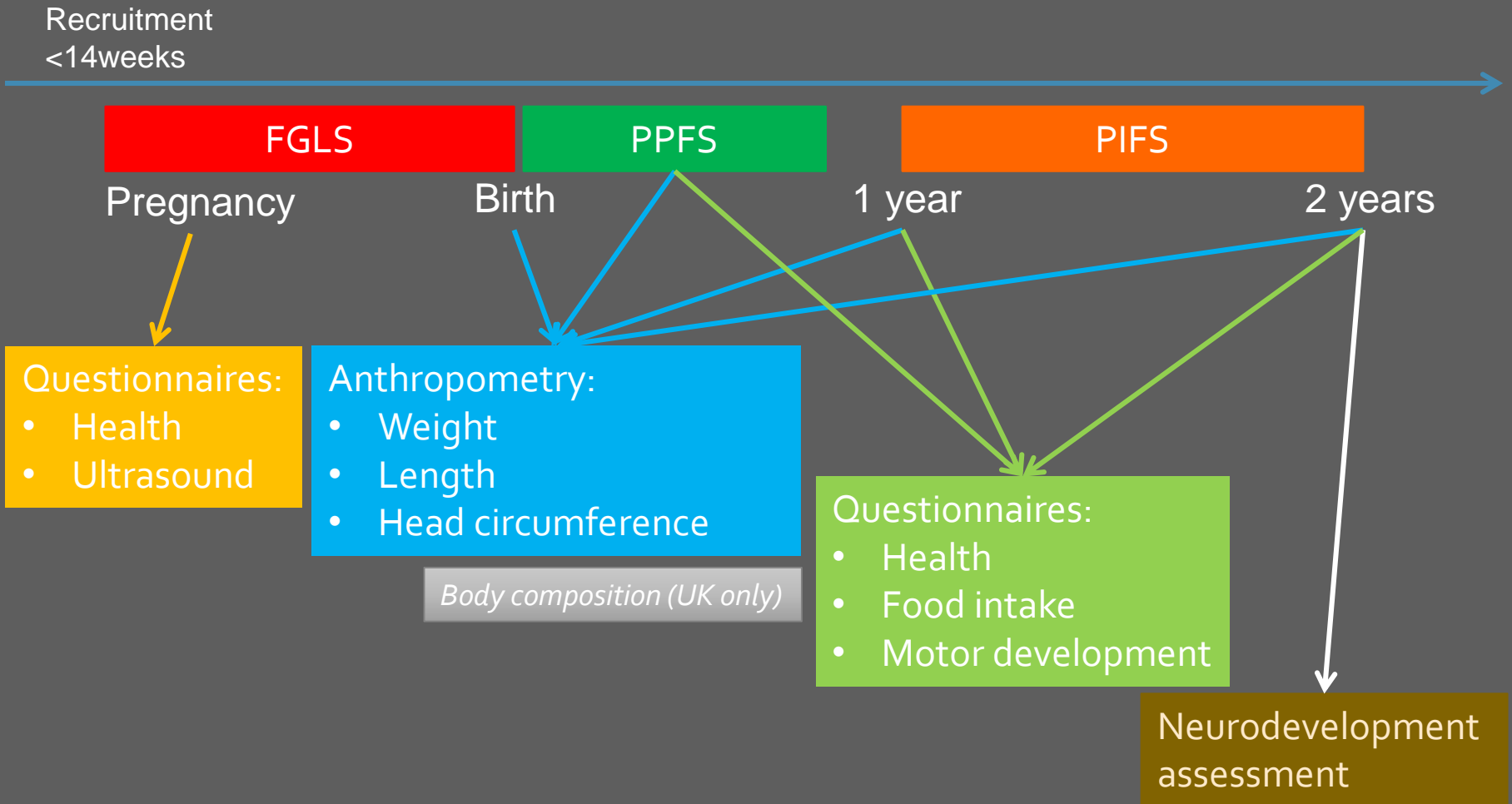
# INTERGROWTH-21<sup>ST</sup> PROJECT

- 1. Fetal Growth Longitudinal Study (FGLS) from <math><14+0</math> weeks gestational age to birth:** to monitor and measure fetal growth clinically and by ultrasound in a healthy population
- 2. Preterm Postnatal Follow-up Study (PPFS) of preterm infants (>26+0 but <math><37+0</math> weeks) in the FGLS** to describe their postnatal growth pattern
- 3. Newborn Cross-sectional Study (NCSS) of all newborns at the study centres over 12 months,** obtaining anthropometric measures and neonatal morbidity and mortality rates

# INTERGROWTH-21<sup>ST</sup> POPULATIONS



# OVERVIEW



# PRODUCTS

## INTERGROWTH-21<sup>st</sup> Project:

Fetal growth

Growth standards:  
HC, AC and FL

Newborn size at birth

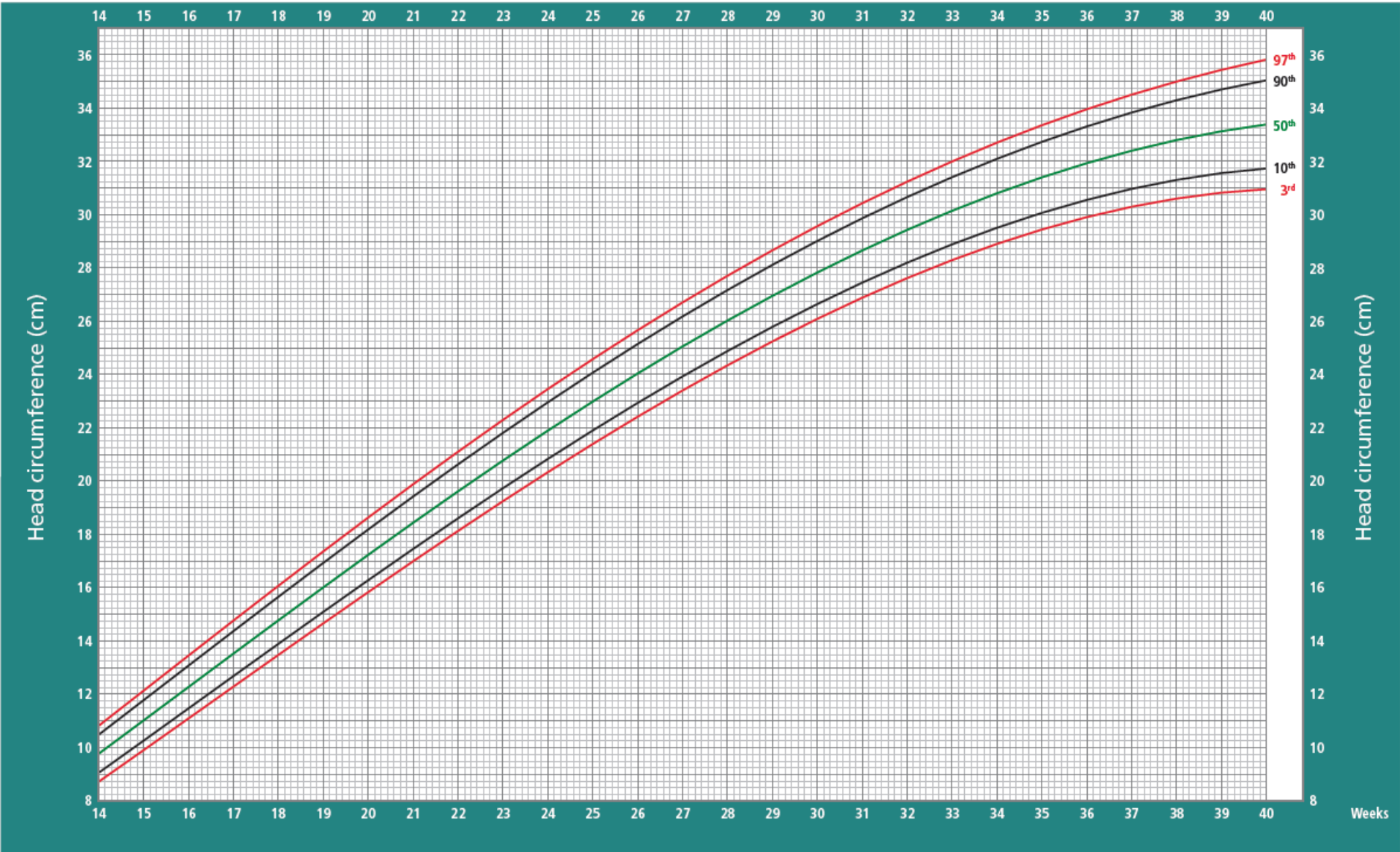
Growth references (27+0 to 32+6 weeks) and standards (33+0 to 42+6 weeks):  
Weight, length, and HC

Postnatal Preterm growth

Growth standards:  
Weight, length, and HC

# International Fetal Growth Standards

## Head circumference





# PRODUCTS

## INTERGROWTH-21<sup>st</sup> Project:

Fetal growth

Growth standards:  
HC, AC and FL

Newborn size at birth

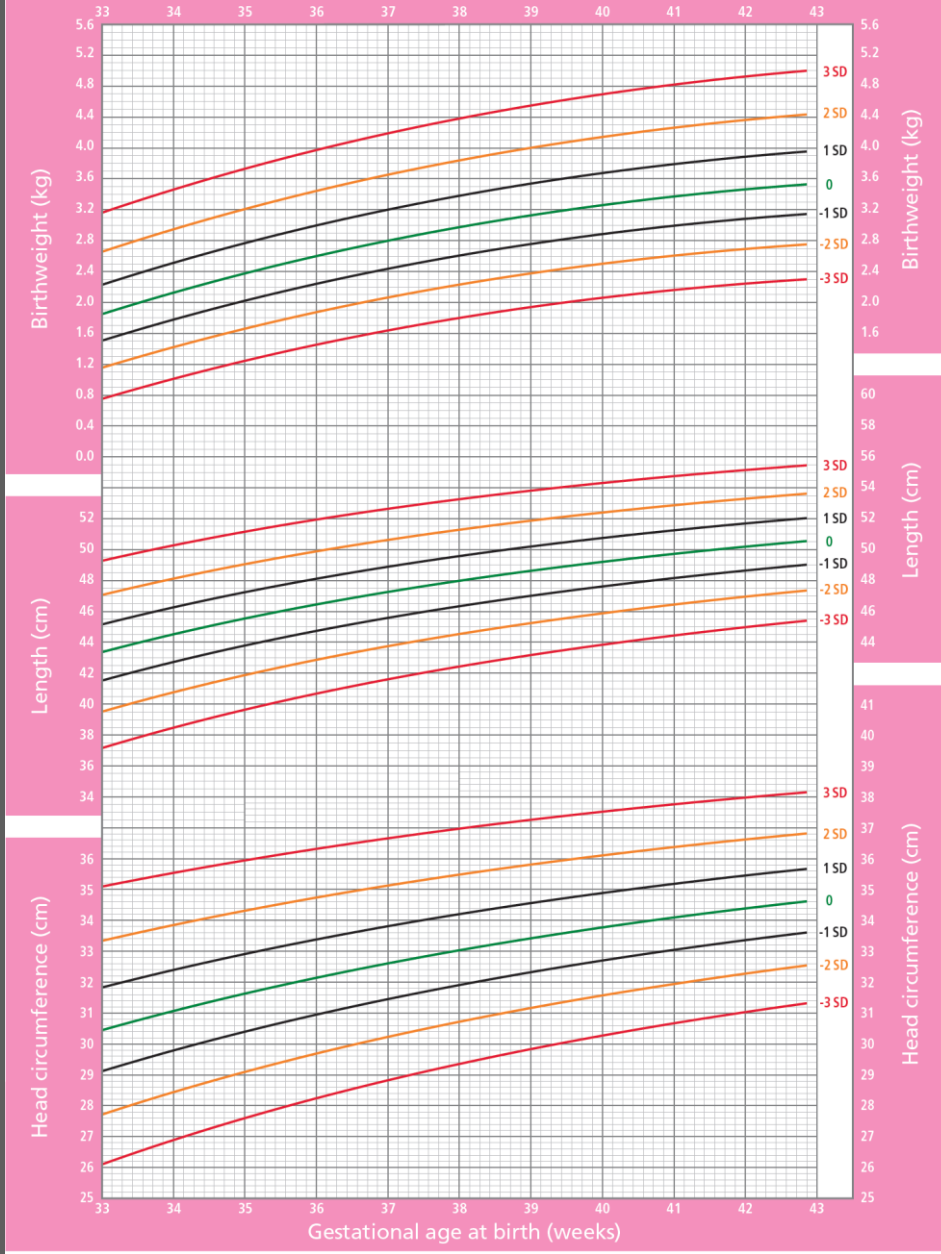
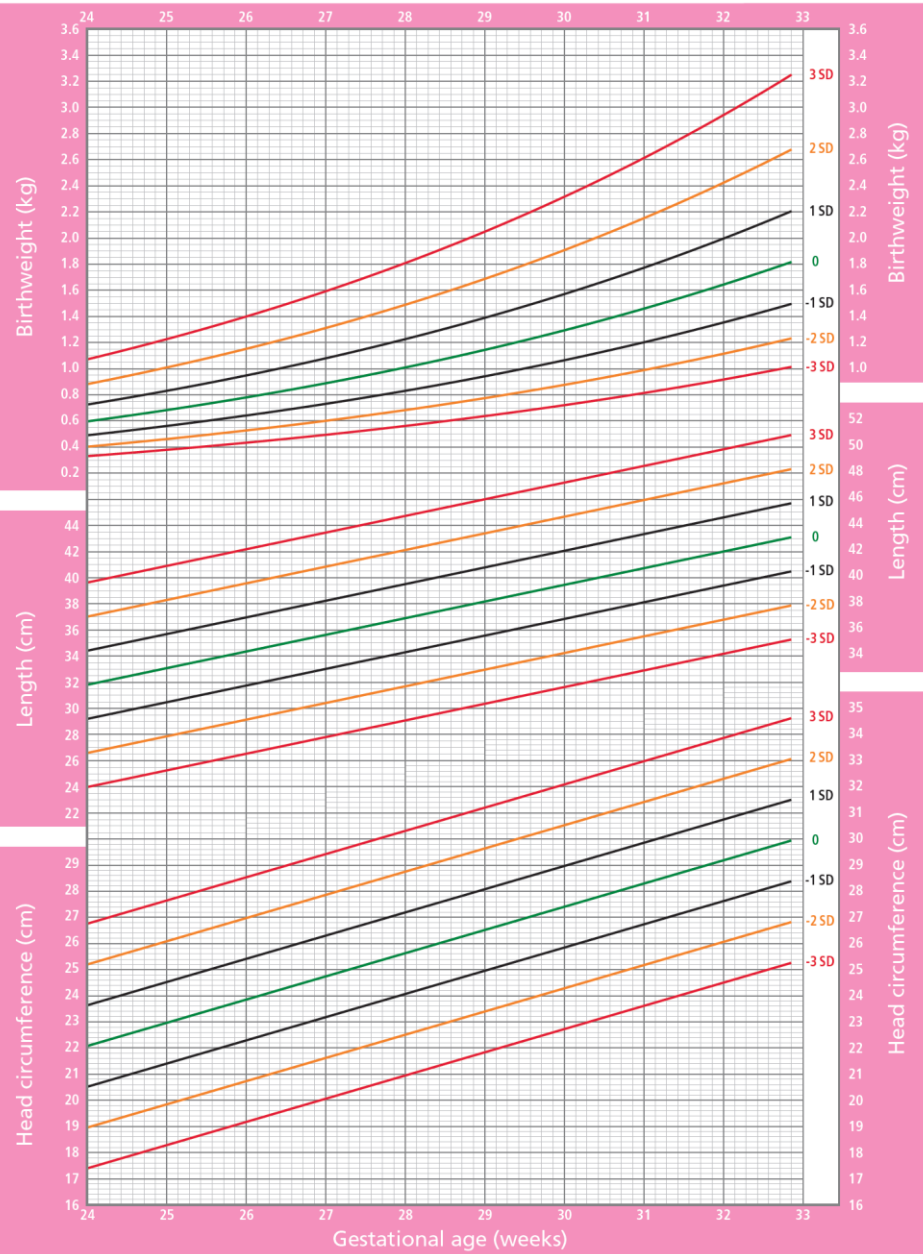
Growth references (27+0 to  
32+6 weeks) and standards  
(33+0 to 42+6 weeks):  
Weight, length, and HC

Postnatal Preterm growth

Growth standards:  
Weight, length, and HC

# International Very Preterm Size at Birth Reference charts (Girls)

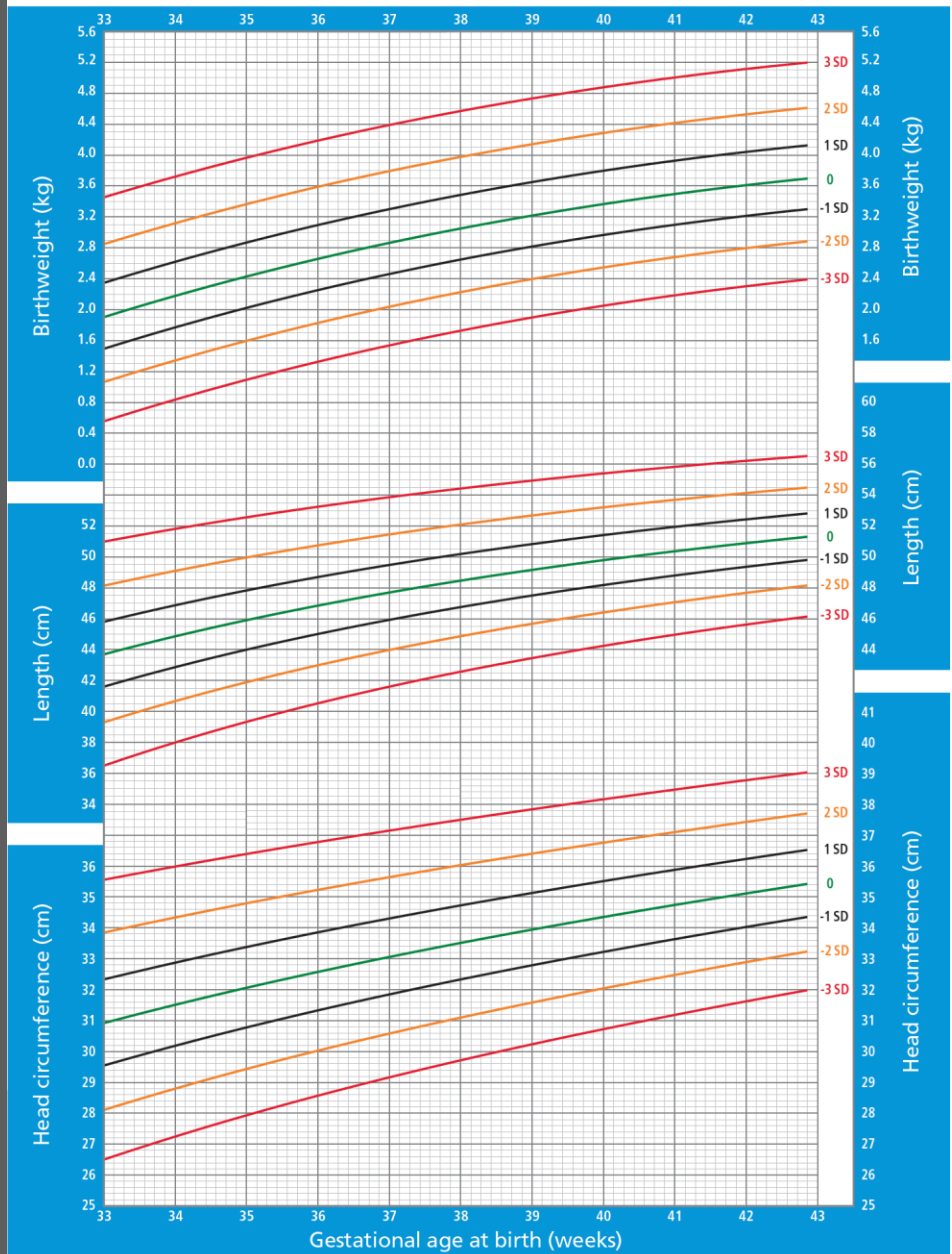
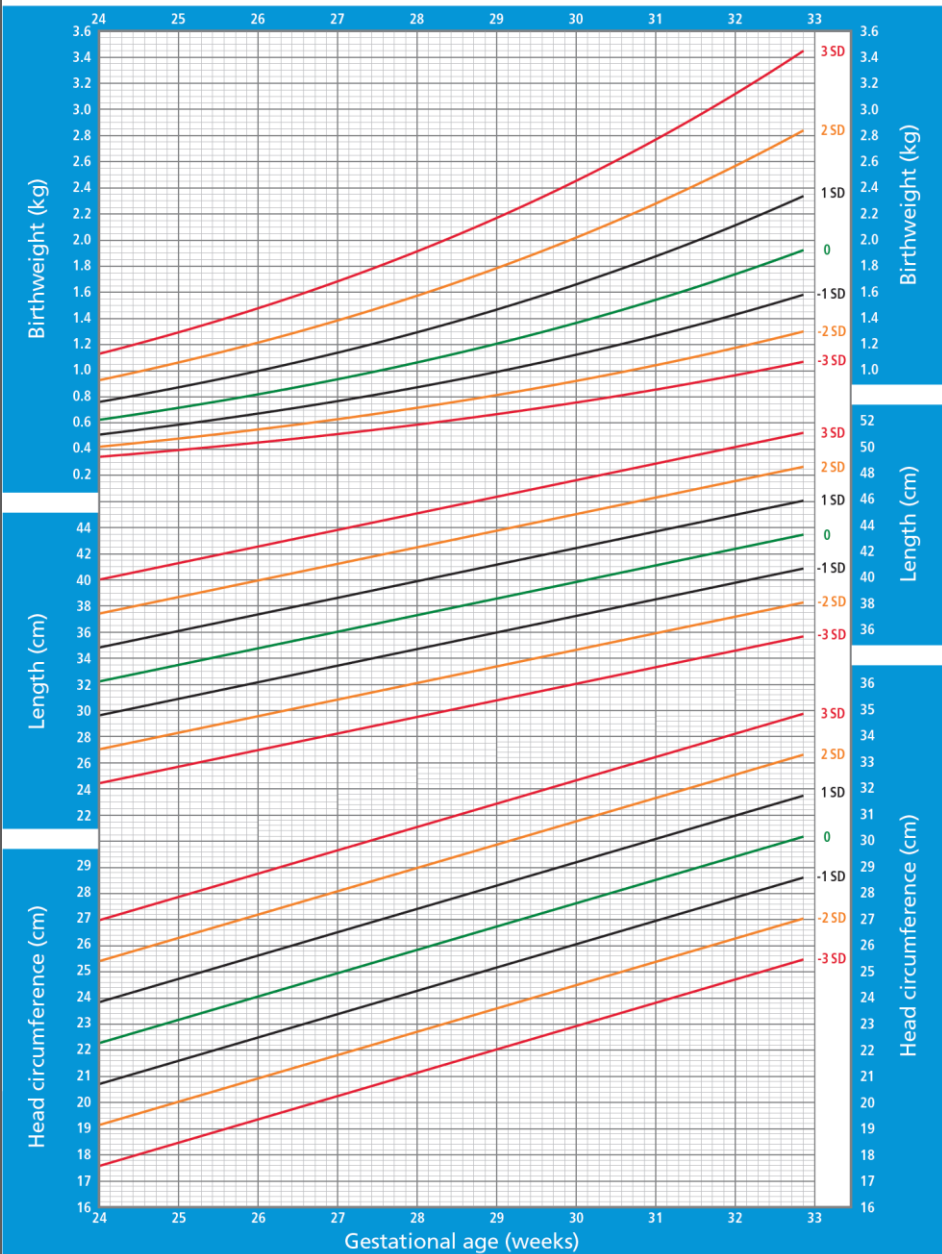
# International Standards for Size at Birth (Girls)



# International Very Preterm Size at Birth Reference charts (Boys)



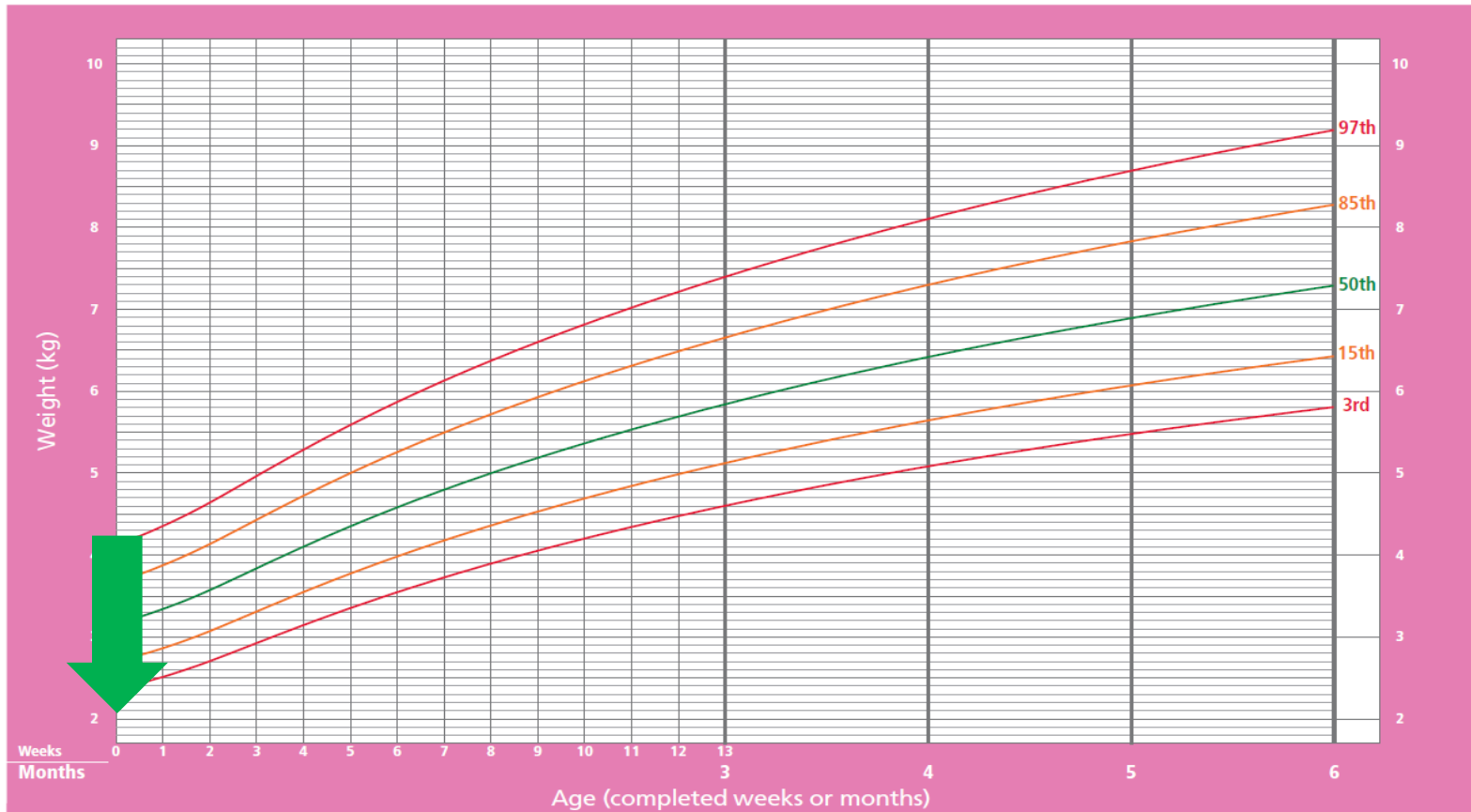
# International Standards for Size at Birth (Boys)



# COMPARISON OF WHO AND INTERGROWTH CHARTS

## Weight-for-age GIRLS

Birth to 6 months (percentiles)



# USING THE WHO'S CHARTS

Baby Melissa's (X) birthweight: 2.82kg

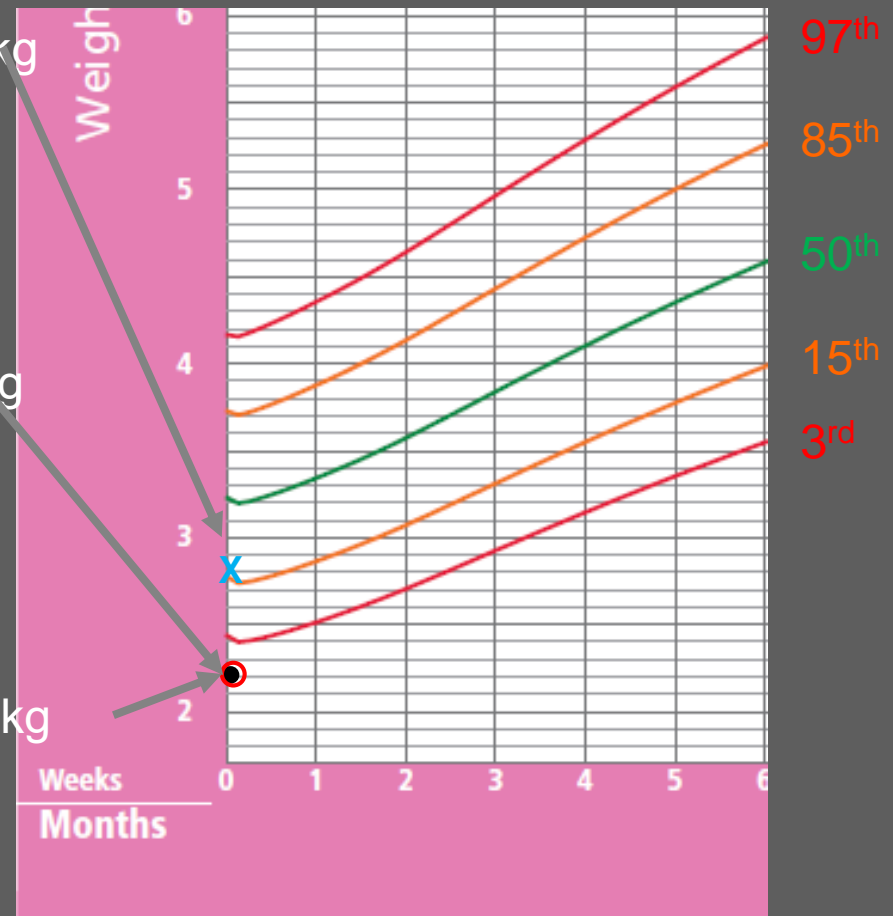
Gestational age: 36+5 weeks

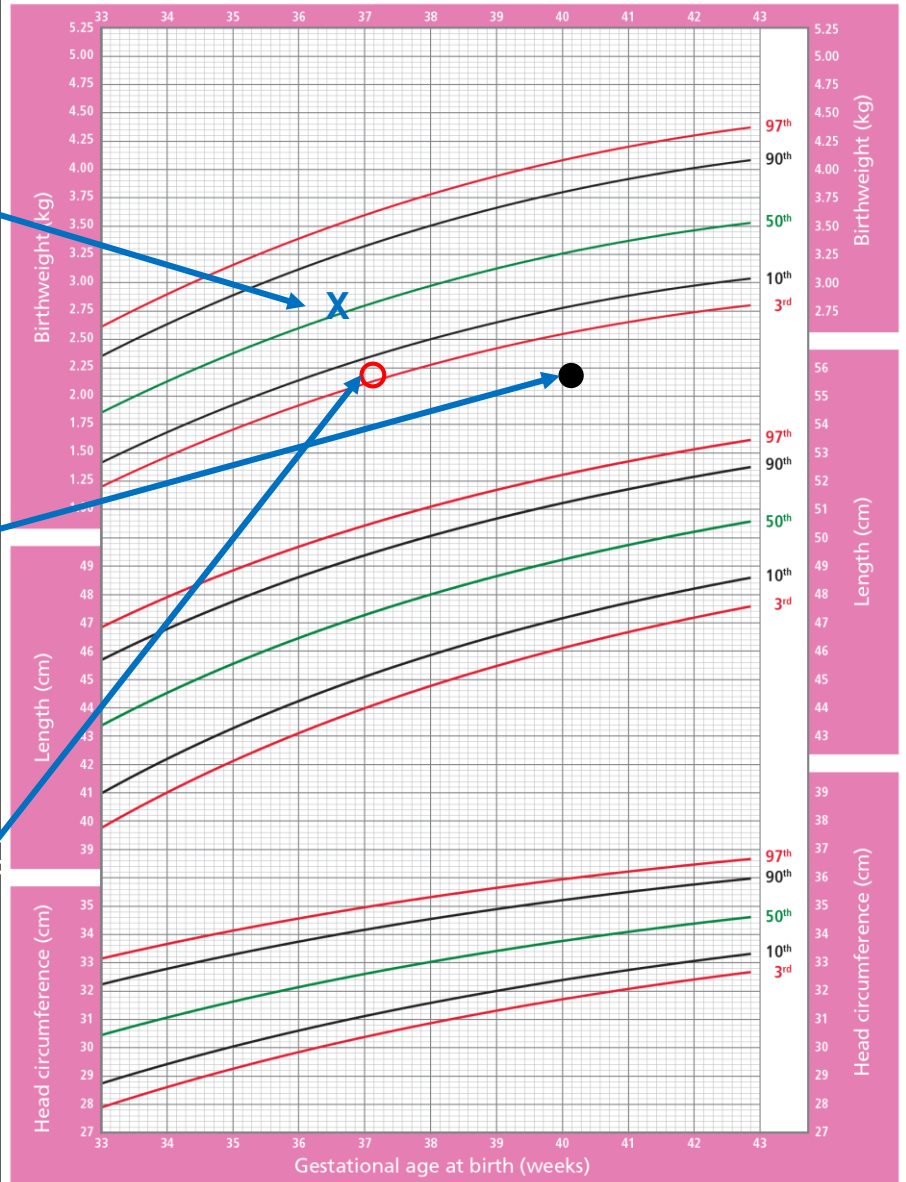
Baby Sophie's (●) birthweight: 2.17kg

Gestational age: 40+1 weeks

Baby Michelle's (○) birthweight: 2.19kg

Gestational age: 37+1 weeks





Baby Melissa's (X) birthweight: 2.82kg  
And GA: 36+5 weeks

Baby Sophie's (●) birthweight: 2.17kg  
and GA: 40+1 weeks

Baby Michelle's (○) birthweight: 2.19kg  
And GA: 37+1 weeks

# PRODUCTS

## INTERGROWTH-21<sup>st</sup> Project:

Fetal growth

Growth standards:

HC, BPD, OFD, AC, and FL

Newborn size at birth

Growth references (27+0 to 32+6 weeks) and standards (33+0 to 42+6 weeks):

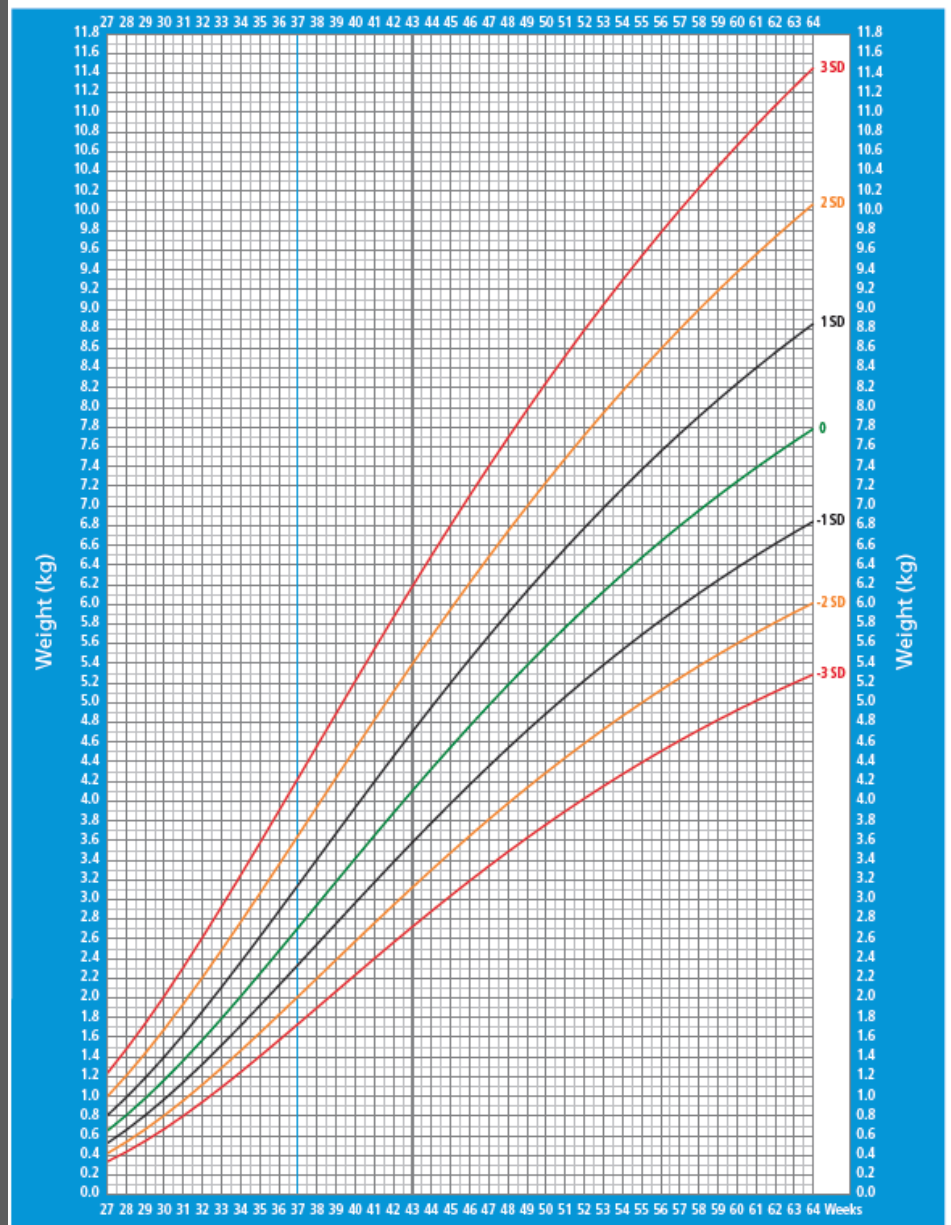
Weight, length, and HC

Postnatal Preterm growth

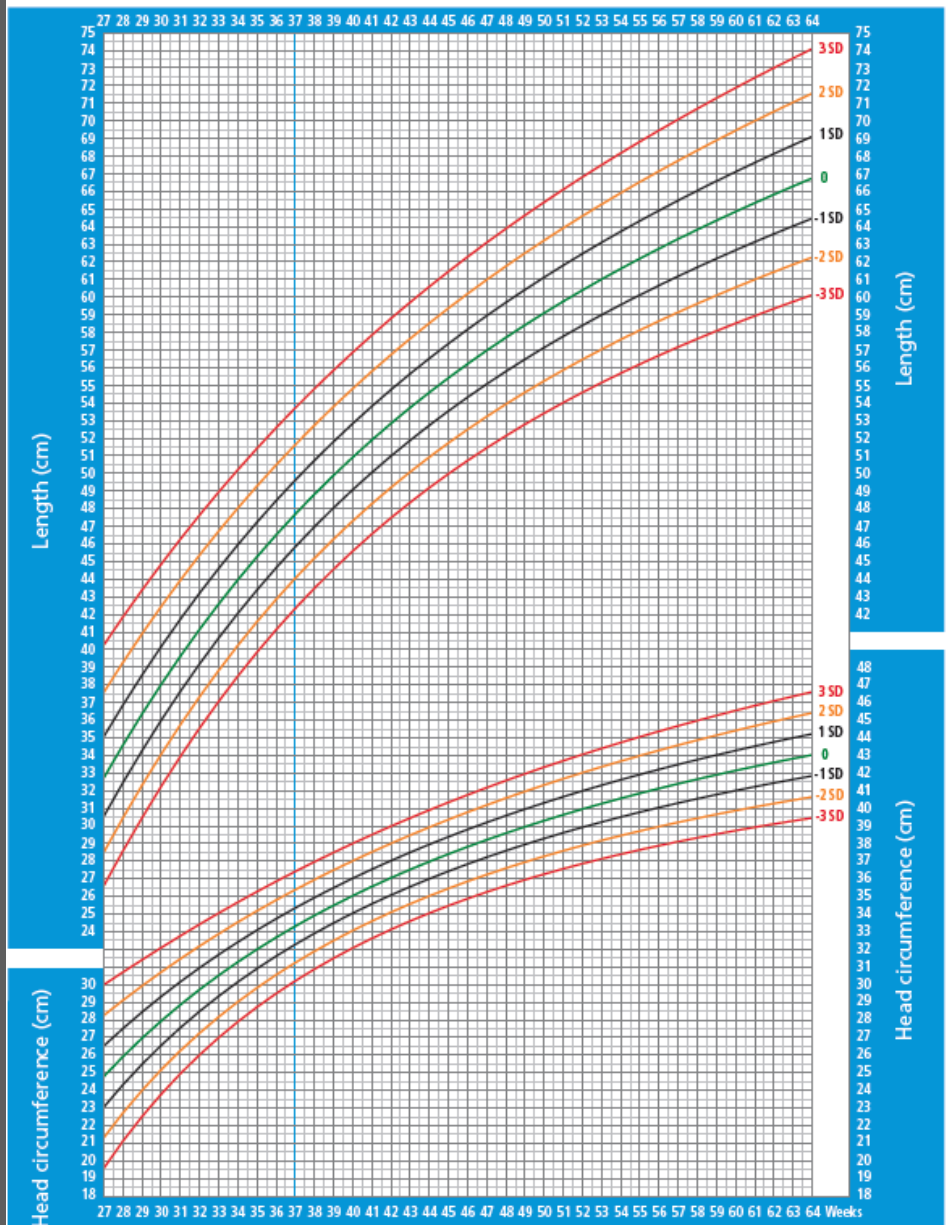
Growth standards:

Weight, length, and HC

# International Postnatal Growth Standards for Preterm Infants (Boys)



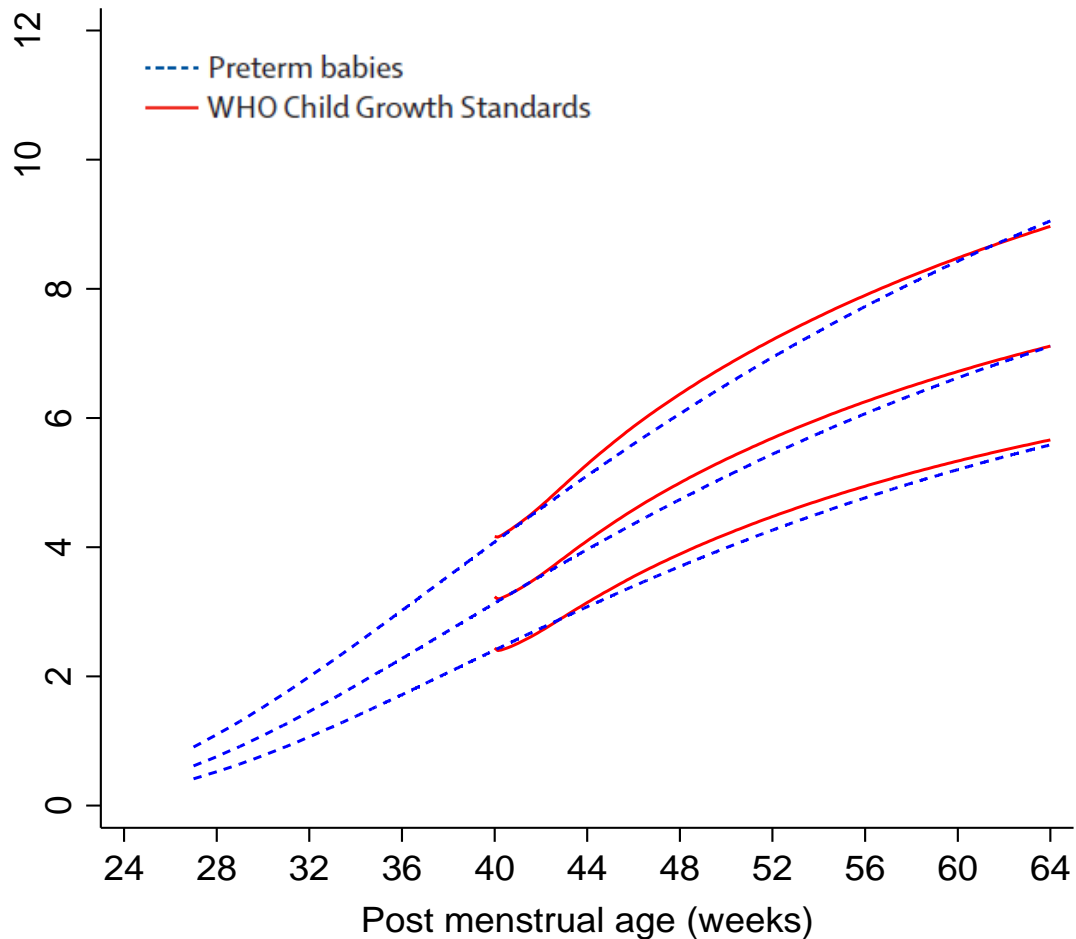
# International Postnatal Growth Standards for Preterm Infants (Boys)



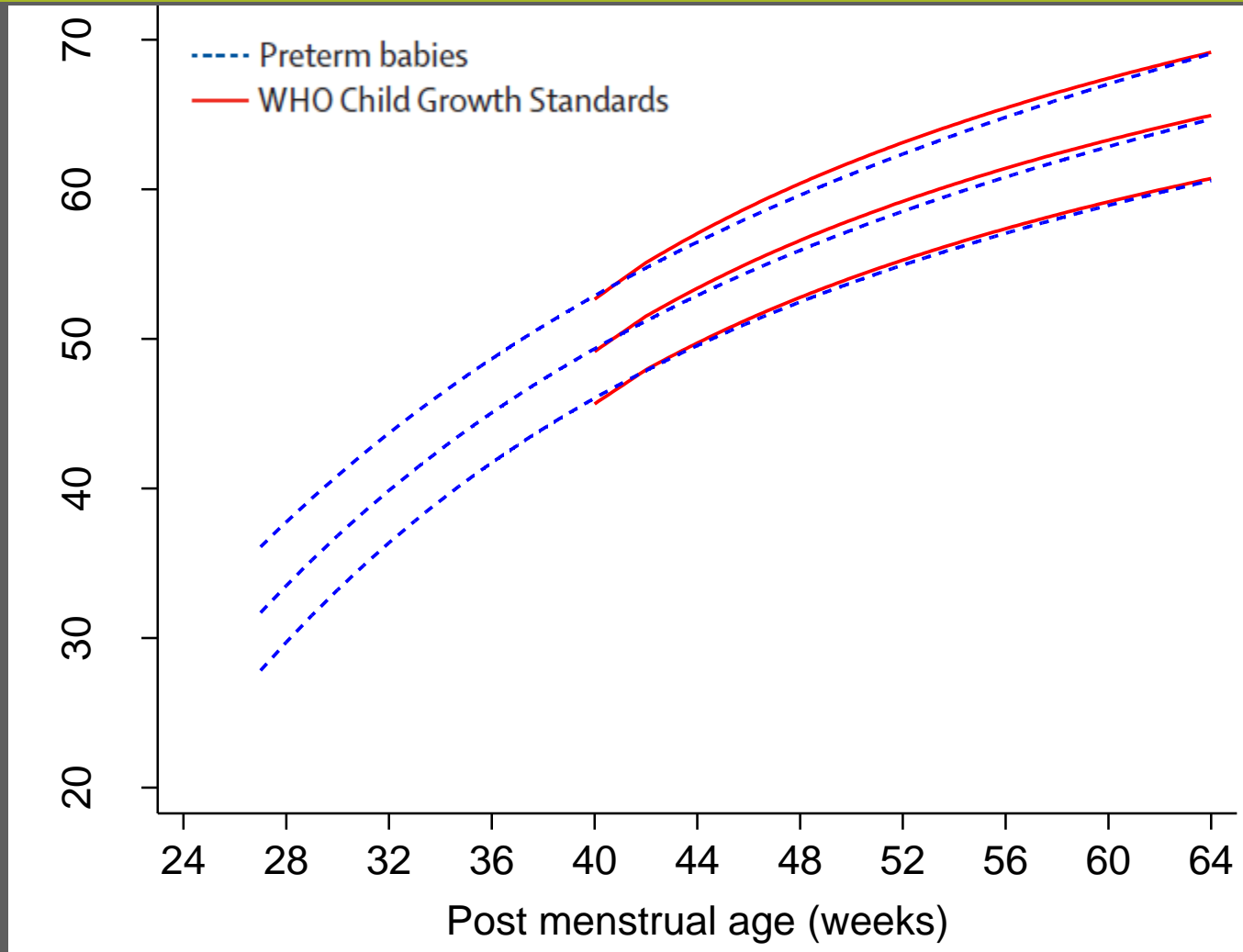


PRETERM POSTNATAL STANDARDS  
VS.  
WHO CHILD GROWTH STANDARDS

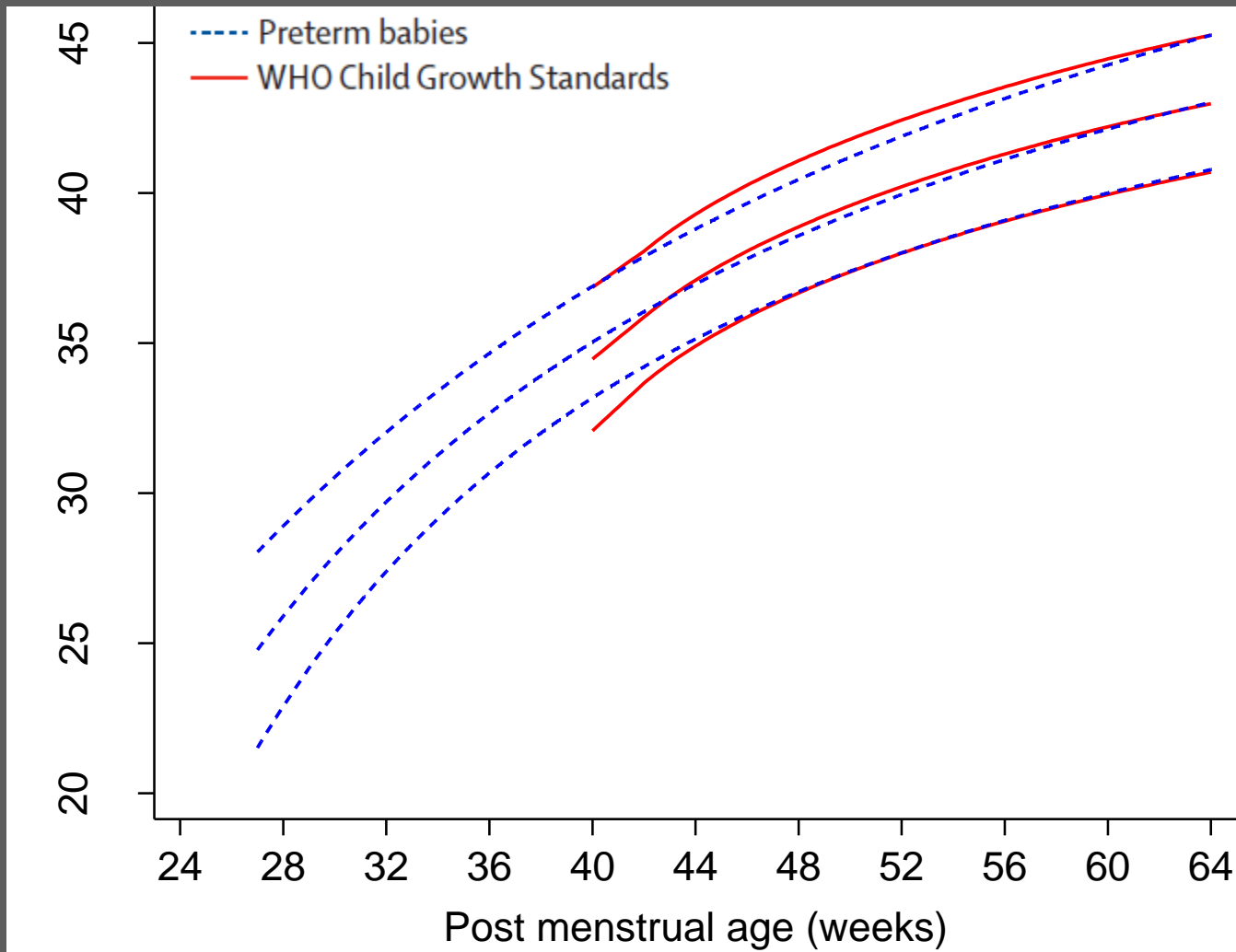
# FITTED 3<sup>RD</sup>, 50<sup>TH</sup>, AND 97<sup>TH</sup> CENTILE CURVES FOR POSTNATAL WEIGHT OVER TIME IN PRETERM BABIES COMPARED WITH THE WHO CHILD GROWTH STANDARDS: GIRLS



# FITTED 3<sup>RD</sup>, 50<sup>TH</sup>, AND 97<sup>TH</sup> CENTILE CURVES FOR POSTNATAL LENGTH OVER TIME IN PRETERM BABIES COMPARED WITH THE WHO CHILD GROWTH STANDARDS: GIRLS



# FITTED 3<sup>RD</sup>, 50<sup>TH</sup>, AND 97<sup>TH</sup> CENTILE CURVES FOR POSTNATAL HEAD CIRCUMFERENCE OVER TIME IN PRETERM BABIES COMPARED WITH THE WHO CHILD GROWTH STANDARDS: BOYS



# PRODUCTS



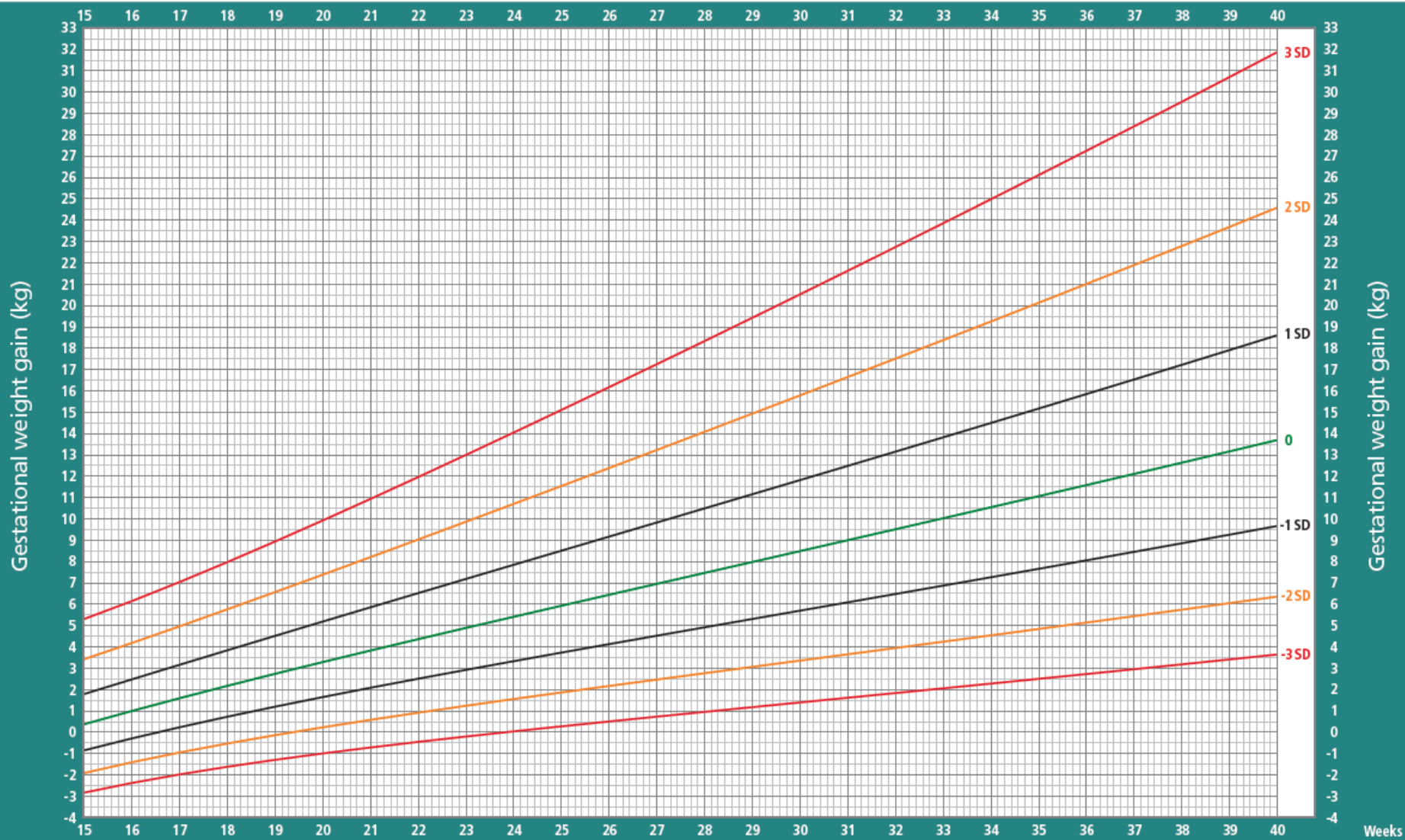
## INTERGROWTH-21<sup>st</sup> Project:

Gestational weight gain

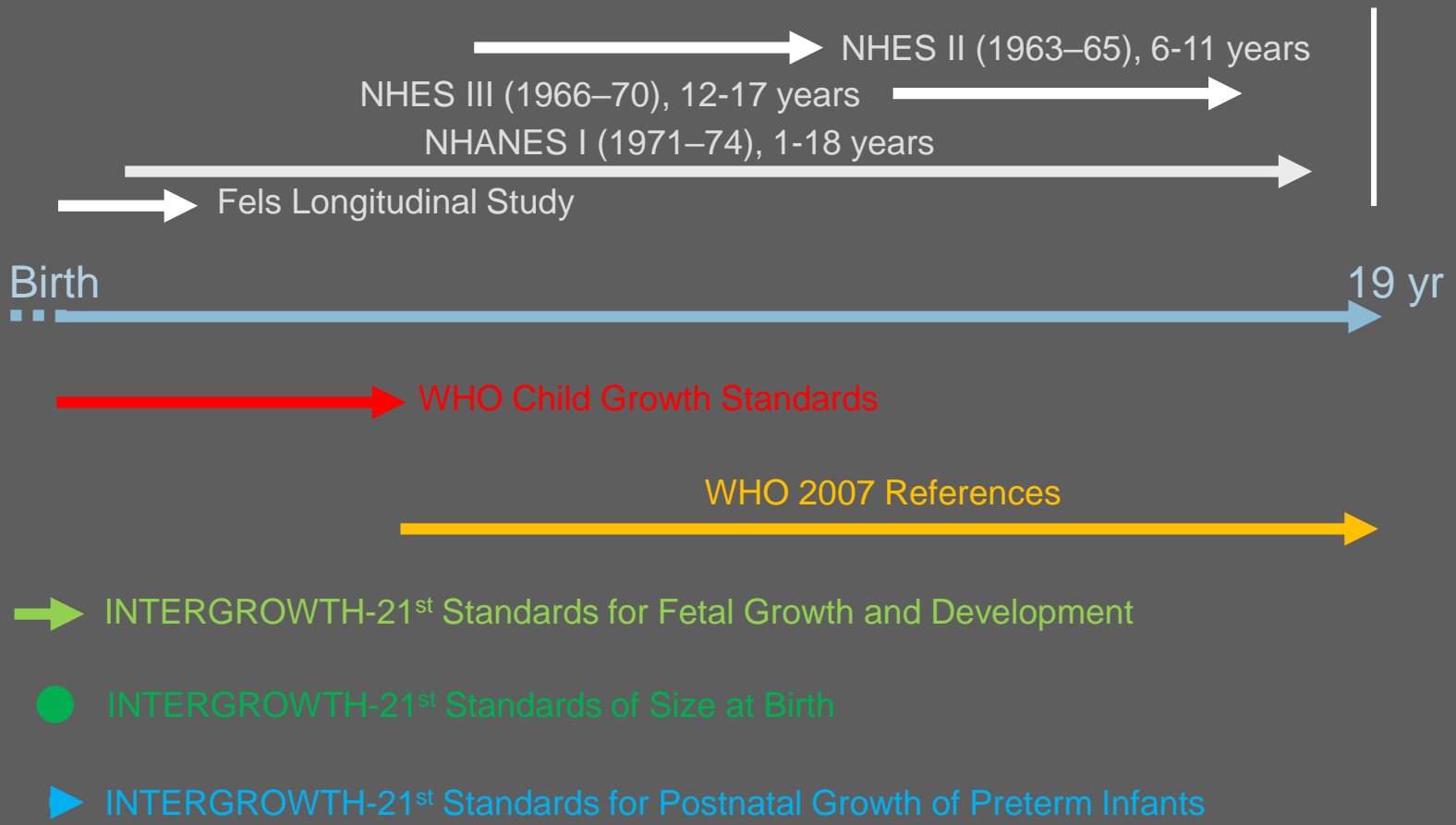
Growth standards:  
women with a normal 1<sup>st</sup>  
trimester BMI

Women, overweight in the  
1<sup>st</sup> trimester (*in preparation*)

# The International Gestational Weight Gain Standards



# CONCLUSION



# CONCLUSION

Growth monitoring promotes continuity of care from the womb to the classroom worldwide

The WHO Child Growth Standards, the WHO Growth Reference 5-19 years, and the INTERGROWTH-21<sup>st</sup> Growth Standards monitor growth from conception up to 19 years of age



# WHO STANDARDS WEBSITE:

HTTP://WWW.WHO.INT/CHILDGROWTH/EN/

World Health Organization

عربي 中文 English Français Русский Español

Health topics Data Media centre Publications Countries Programmes Governance About WHO

## Child growth standards

**Child growth standards**

- The Multicentre Growth Reference Study
- Standards
- Training
- Software
- Publications
- Frequently asked questions

### The WHO Child Growth Standards

This web site presents the WHO Child Growth Standards. These standards were developed using data collected in the WHO Multicentre Growth Reference Study. The site presents documentation on how the physical growth curves and motor milestone windows of achievement were developed as well as application tools to support implementation of the standards.

Now training course available in Russian

#### Related links

- Growth reference, 5-19 years
- Multimedia help
- The launch
- The Healthy Growth Project
- WHO Department of Nutrition for Health and Development
- WHO Department of Child and Adolescent Health and Development
- WHO Global Database on Child Growth and Malnutrition

#### Basic Guidelines

- WHO child growth standards and the identification of severe acute malnutrition in infants and children
- Guiding principles for complementary feeding of the breastfed child | versión española
- HIV and infant feeding counselling tools: Reference Guide

#### Endorsements

- The European Childhood Obesity Group pdf, 73kb
- International Pediatric Association pdf, 94kb
- UN Standing Committee on Nutrition pdf, 94kb
- International Union of Nutrition Sciences pdf, 23kb

Child growth standards

World Health Organization

Sitemap  
Home  
Health topics  
Data

Help and Services  
Contacts  
FAQs  
Employment

WHO Regional Offices  
WHO African Region  
WHO Region of the Americas  
WHO South-East Asia Region

# WHO REFERENCE WEBSITE:

HTTP://WWW.WHO.INT/GROWTHREF/EN/



The screenshot shows the WHO Reference website for 5-19 years. The page features a blue header with the WHO logo and navigation links in multiple languages. A blue navigation bar contains links for Health topics, Data, Media centre, Publications, Countries, Programmes, Governance, and About WHO. The main content area is titled "Growth reference 5-19 years" and includes a sidebar with links for Growth reference 5-19 years, Application tools, and Related publications. The central section is titled "Growth reference data for 5-19 years" and features a large graphic of the WHO Reference 2007 logo, which is a colorful illustration of children playing. Below the logo, there is a section titled "Macro in R" with a text box explaining that an additional macro is available for nutritional status analysis. The page also includes a "Key WHO Information" sidebar with links to Director-General, Governance of WHO, Media centre, International travel and health, and World Health Report.

World Health Organization

English Français Русский Español

Home Health topics Data Media centre Publications Countries Programmes Governance About WHO Search

## Growth reference 5-19 years

- Growth reference 5-19 years
- Application tools
- Related publications

### Growth reference data for 5-19 years



**Key WHO Information**

- Director-General  
Director-General and senior management
- Governance of WHO  
WHO Constitution, Executive Board and World Health Assembly
- Media centre  
News, events, fact sheets, multimedia and contacts
- International travel and health  
Publication on travel risks, precautions and vaccination requirements
- World Health Report  
Annual report on global public health and key statistics

**Macro in R**

An additional macro is now available to facilitate analysis of nutritional status in children and adolescents 5-19 years using R (see Application tools).

This web site presents growth reference data for children and adolescents, 5-19 years (or 61-228 months).

The WHO Reference 2007 is a reconstruction of the 1977 National Center for Health Statistics (NCHS)/WHO reference. It uses the original NCHS data set supplemented with data from the WHO child growth standards sample for under-fives. To develop this reference the same statistical methodology was used as in the construction of the WHO standards.

This reference complements the WHO child growth standards for 0-60 months published in April 2006 (see link on right column).

**Documentation**

The following article describes the sample and methods used to construct this growth reference.

Development of a WHO growth reference for school-aged children and adolescents

**Indicators**

The links below provide access to the reference charts and tables by indicator.

# INTERGROWTH-21<sup>ST</sup> WEBSITE:

HTTPS://INTERGROWTH21.TGHN.ORG/



## INTERGROWTH-21<sup>st</sup>

THE INTERNATIONAL FETAL AND NEWBORN GROWTH CONSORTIUM FOR THE 21<sup>ST</sup> CENTURY

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### Research centres



## The International Fetal and Newborn Growth Consortium for the 21<sup>st</sup> Century



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The International Fetal and Newborn Growth Consortium for the 21<sup>st</sup> Century, or INTERGROWTH-21<sup>st</sup>, is a global, multidisciplinary network of more than 300 researchers and clinicians from 27 institutions in 18 countries worldwide and coordinated from the University of Oxford. We are dedicated to improving perinatal health globally and committed to reducing the millions of preventable newborn deaths that occur as a result of preterm birth or poor intrauterine growth.

### Newborns and very preterm babies reference application

Zika Virus - In response to the recent news about the Zika virus, we draw your attention to the International INTERGROWTH-21<sup>st</sup> Standards for Head Circumference of newborns and very preterm babies online application tool.

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### Zika Virus

In response to the recent news about the Zika virus, we draw your attention to the International INTERGROWTH-21<sup>st</sup> Standards for Head Circumference of newborns and very preterm infants.

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### News

INTERGROWTH 21<sup>st</sup> - Head circumference training video

This website provides clinicians and researchers access to the INTERGROWTH-21<sup>st</sup> Global Perinatal Package. This package is comprised of new, globally-

(Access the translated

THANK YOU!