Childhood obesity
Definitions and reference populations

U.S. DEPARTMENT OF HEALTH AND HUMAN SERVICES
Centers for Disease Control and Prevention
National Center for Health Statistics
Children and teens, 2-19 years, 2007-2008

- 16.9% obese
  - About 12.5 million children
- 31.7% Overweight or obese
  - ~23.4 million children

Source: Ogden et al. 2010, JAMA; NHANES 2007-8
Defining Obesity and Overweight
Obesity

- Excess adipose tissue
  - Often impractical to measure

- Excess weight for height
  - Easy to obtain
  - A proxy for adiposity, highly correlated
  - Various indices
Body mass index (BMI)

- BMI = weight (kg)/height (m)^2
- Measure of weight adjusted for height
- Does not distinguish between body fat and muscle
- Recommended for adults, adolescents & children
Using BMI in childhood

- BMI varies with age and sex

- Unlike in adults, no risk based cutoffs exist

- Statistical definition
  - BMI-for-age
  - Percentiles from a reference population
  - Often the 2000 CDC growth charts
Recommended cut points & labels, 1990s

2-19 years

\[ \geq 85^{th} \text{ but } < 95^{th} \text{ percentile} \]
“At risk for overweight”

\[ \geq 95^{th} \text{ percentile} \]
“Overweight”


“Overweight”

… children who were overweight by this definition should be screened for possible obesity-related conditions...
“At risk for overweight”

Children who were at risk for overweight using this definition…. should be referred to a second level screen. … If youths are positive on … the second level screen they should be referred for further medical assessment.
New recommendations in 2007

- No change in cut points

- Change in labels
  - $\geq 95^{th}$ percentile: “Obese” more effectively conveys the seriousness, urgency, and medical nature of this concern than does the term “overweight,” thereby reinforcing the importance of taking immediate action.
  - $\geq 85^{th}$ but $< 95^{th}$ percentile: “Overweight”

HHS has adopted these new labels

Stating

…Although these cut points are not diagnostic criteria, elevated BMI among children most often indicates increased risk for future adverse health outcomes and/or development of disease.

Surgeon General’s Vision for a Healthy and Fit Nation
CDC Growth Charts: United States
BMI-for-age: boys 2 to 20 years

95th percentile

85th percentile
## Prevalence (SE) of high body mass index (BMI), US children 2-19 years

<table>
<thead>
<tr>
<th>Definition</th>
<th>2005-2006</th>
<th>2007-2008</th>
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</thead>
<tbody>
<tr>
<td><strong>BMI-for-age&gt;= 95th percentile</strong>*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Old terminology: Overweight</td>
<td>15.5 (1.3)</td>
<td>16.9 (1.3)</td>
</tr>
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<td>16.9 (1.3)</td>
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<td><strong>BMI-for-age&gt;= 85th percentile</strong>*</td>
<td></td>
<td></td>
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<tr>
<td>Old terminology: At risk for overweight or overweight</td>
<td>30.1 (1.6)</td>
<td>31.7 (1.2)</td>
</tr>
<tr>
<td>New terminology: Overweight or obese</td>
<td>30.1 (1.6)</td>
<td>31.7 (1.2)</td>
</tr>
</tbody>
</table>

Source: CDC/NCHS, National Health and Nutrition Examination Survey

*On the sex specific CDC growth charts
Infants birth to 2 years of age

- No agreed upon definition

- $\geq 95^{\text{th}}$ percentile of weight-for-recumbent length of CDC growth charts often used in US
  - No BMI curves for birth-2 years on CDC charts
Reference Populations

- CDC growth charts, birth-19 years
- WHO growth standards, birth-4 years
- WHO growth references, 5-19 years
- IOTF international references, 2-18 years
- Countries have their own growth references
Workshop, June 2006

• Here at NCHS
• Co-sponsored by
  – CDC (NCHS, NCCDPHP), NIH, and AAP
• Discussed
  – Differences between CDC and WHO charts (birth-4 years)
  – Potential use of the WHO charts (birth-4 years) in US
• Outcomes:
  – Descriptive MMWR currently in press
  – Recommendations
CDC 2000 growth charts

• Infants, birth-36 mo
  – Head circumference-for-age
  – Weight-for-age
  – Length-for-age
  – Weight-for-length

• 2-4 years
  – Weight-for-stature

• 2-20 years
  – Weight-for-age
  – Stature-for-age
  – BMI-for-age
Data

• US population 60s-early 90s
  – Excluded VLBW infants
  – Excluded weight data from 1988-94 for ages 6+
  – Additional supplemental data
• Racially and ethnically diverse
• Distribution of breast feeding 60s-early 90s
• General reference not a standard
Specific data sources

• National Health Examination Survey (NHES)
  – cycle 2 1963-65
  – cycle 3 1966-70
• National Health and Nutrition Examination Survey
  – NHANES I 1971-74
  – NHANES II 1976-80
  – NHANES III 1988-94 (<6 years weight; length/stature)
• National birth weight distribution
• Wisconsin and Missouri birth length
• Fels head circumference at birth
• Pediatric Nutrition Surveillance System (PedNSS)
  – length data <5 months
Reference Data Sets: Birth to 36 Months

<table>
<thead>
<tr>
<th>Age in Months</th>
<th>B</th>
<th>3</th>
<th>6</th>
<th>9</th>
<th>12</th>
<th>15</th>
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<td>Weight-for-Length</td>
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- MO/WI Natality
- National Natality
- PedNSS
- Fels
- NHANES III ('88-'94)
- NHANES II ('76-'80)
- NHANES I ('71-'74)
Reference Data Sets: Birth to 36 Months

- Head Circum
- Length
- Weight
- Weight-for-Length

Age in Months

- MO/WI Natality
- National Natality
- PedNSS
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- NHANES III ('88-'94)
- NHANES II ('76-'80)
- NHANES I ('71-'74)
Reference Data Sets: 2 to 20 Years

Age in years

Stature

Weight/BMI

NHANES III ('88-'94)  NHANES II ('76-'80)  NHANES I ('71-'74)
NHES III ('66-'70)  NHES II ('63-'65)
CDC growth charts, concerns

- Lack of data from birth-2 months
- PedNSS data added for length
2006 WHO growth charts, birth-4 years

• Multicentre growth reference study (MGRS)

• Prescriptive reference or standard
  – Describes how children should grow
Prescriptive approach

• Optimal Nutrition
  – Breastfeeding
  – Appropriate complementary feeding

• Optimal Environment
  – Clean water & plumbing
  – No smoking

• Optimal Care
  – Immunization
  – Pediatric well care visits
2006 WHO growth charts

• Birth-4 years
  – Length/height-for-age
  – Weight-for-age
  – Weight-for-length/height
  – Body mass index-for-age
  – Head circumference-for-age
  – Mid-upper arm circumference-for-age
  – Subscapular skinfold-for-age
  – Triceps skinfold-for-age
  – Motor development milestones
Study Design

Two Components

- Longitudinal study (0-24 months)
  - frequent assessments of feeding and growth (21)
  - strong breastfeeding support

- Cross-sectional study (18-71 months)
  - feeding mode no longer critical for curve
  - overlap to improve merging of two curves
Site selection

• Pelotas, Brazil
• Accra, Ghana
• South Delhi, India
• Oslo, Norway
• Muscat, Oman
• Davis, CA, USA
Eligibility of Study *Population*

- Relatively high SES
- Altitude < 1,500 m
- Low mobility in the population
- Minimum 20% of moms follow feeding recommendations
- Breastfeeding support system exist
- Collaborative institutions
Eligibility of *Individuals*

- No health, environmental, economic constraints on growth
- Lack of significant perinatal morbidity
- Mother willing to follow feeding recommendations
  - Predominant breast feeding for at least 12 months
  - Complementary foods introduced between 4 & 6 mo
- Non smoking mothers (before and after delivery)
- Term birth
- Single birth
### Table 1  Total sample and number of compliant children in the longitudinal component

<table>
<thead>
<tr>
<th>Site</th>
<th>N</th>
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<tr>
<td></td>
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<td>Boys</td>
<td>Girls</td>
<td>Total</td>
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<td>USA</td>
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<td>64</td>
<td>55</td>
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<tr>
<td>All</td>
<td>1737</td>
<td>428</td>
<td>454</td>
<td>882</td>
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<sup>a</sup> Compliant with infant-feeding and no-smoking criteria and completed the 24-month follow-up.
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<sup>a</sup> Compliant with infant-feeding and no-smoking criteria and completed the 24-month follow-up.
2006 WHO Data Exclusions

- **Longitudinal**
  - Observations falling above $+3 \text{ SD}$ or below $-3 \text{ SD}$ of the sample median (weight-for-length)

- **Cross sectional**
  - Observations falling above $+2 \text{ SD}$ (weight-for-stature)
CDC versus WHO charts

- **Data**
  - Reference v standard

- **Methods**
  - Smoothing different but some similarities (LMS parameters)

- **Comparison of actual curves**
  - Different in first 2 years of life
  - Not so different after age 2-3 years
Sample selection

- **CDC**
  - Primary data from 5 US national surveys
  - Supplementary data at birth and in first months of life
- **WHO**
  - 6 sites
  - High SES
  - No health constraints to growth
  - Singleton, term births
  - No maternal smoking
  - Feeding
    - CS: breastfeeding at least 3 months
    - LS: mother willing to follow feeding recommendations
Exclusions

- **CDC**
  - Very low birth weight (<1500 g)
  - Weight, children 6+ years, NHANES III (1988-1994)
  - 13 children for large length-stature discrepancies (n=11) or outlying influential points (n=2)

- **WHO**
  - + 2 SD weight-for-height CS
  - +/- 3 SD weight-for-length LS
Main difference

• DATA
  – Sample selection

• Reference versus standard
Thank you
Trends in obesity* among children and adolescents

*Obesity defined as body mass index (BMI) $\geq$ gender and age specific 95th percentile from the 2000 CDC Growth Charts.
Source: National Health Examination Surveys II (ages 6-11) and III (ages 12-17), National Health and Nutrition Examination Surveys I, II, III and 1999-2008, NCHS, CDC.
CDC charts, features

- Descriptive reference not standard
- No race/ethnic specific charts
- Include BMI-for-age
  - $85^{\text{th}}$ percentile included
- Percentiles and z-scores agree
- Correction of disjunction
- 3rd and 97th percentiles included
2000 CDC charts

• General reference

• Exclusions
  – Very low birth weight infants (<1500 grams)
  – 1988-1994 weight data for 6 years and older
    (All weight related charts)
PedNSS

- Primarily from clinical records of the Special Supplemental Nutrition Program for Women, Infants and Children (WIC)
  - Low income

- Subset of clinics
  - 213 clinics
  - 1975-1995
  - Mean length and weight +/-0.5cm and +/-0.5 kg of mean from NHANES II and III by month of age
  - SD within +/-0.2cm and +/-0.2kg
  - Skewness in weight +/-10.3kg of skewness
Breast feeding

• Include both breast and formula fed infants proportional to the distribution in the population at time of data collection
  – ~ 50% of infants received some breast milk
  – ~ 33% were breast fed for 3 months or more
• Most recent data (1999-2001) in US*
  – 66% breast fed
• National Survey of Child Health (2003-04)
  – ~17% of 1-5 year olds breast fed for 12+ months

*Health, United States, 2006
WHO (2007) Reference, 5-19 years

- **Data**
  - HES II, HES III, NHANES I (from 1978 version)

- **Methods**
  - Smoothing identical to that used in the standards
  - Includes same exclusions based on same ‘outliers’

- **Smooth transition between standard and reference**
  - Included some data from sectional study of MGRS
WHO growth charts

• 2006 **standards** for birth to age 5 based on Multicentre growth reference study (MGRS)
  – Prescriptive reference or standard
  – Describes how children should grow

• 2007 school age and teen **reference**
How do the charts compare?

- Visually
- Data
- Exclusions
- Smoothing
- Use of charts
  - Cut-points
Figure 16  Comparison of WHO with CDC 2000 length/height-for-age z-scores for boys
Figure 59  Comparison of WHO with CDC 2000 weight-for-age z-scores for girls
Figure 77  Comparison of WHO with CDC 2000 weight-for-length z-scores for boys
Figure 78  Comparison of WHO with CDC 2000 weight-for-height z-scores for boys
Figure 115  Comparison of WHO with CDC 2000 BMI-for-age z-scores for boys
Figure 115  Comparison of WHO with CDC 2000 BMI-for-age z-scores for boys
Effect of applying the +/- 2 SD criterion to the CDC sample

Agreement with the WHO charts was better at higher percentiles with the recalculated values.
Difference in weight between WHO and CDC charts with and without data exclusions

1. Weight for length

Source: NHANES 1999-2004; Flegal et al under review
Difference in weight between WHO and CDC charts with and without data exclusions

2. Weight for height

Source: NHANES 1999-2004; Flegal et al under review
Difference in BMI between WHO and CDC charts with and without data exclusions

3. BMI-for-age

Source: NHANES 1999-2004; Flegal et al under review
Weight for height boys +2 SD exclusions

- 3rd
- 50th
- 85th
- 97th

--- CDC
--- WHO
Weight for height

girls +/- 2 SD exclusions

--- CDC
--- WHO
Smoothing methods

The WHO standards ... employed LMS-based methods that fit skewed data adequately and generate fitted curves that follow closely the empirical data. Like the WHO standards, construction of the CDC 2000 growth charts was also based on the LMS method and, therefore, differences between this reference and the WHO standards are largely a reflection of differences in the populations on which the two sets of curves were based.”

» Technical report, p xviii
Using the charts: cut-offs for abnormal growth

- Cut-off values are statistical and not functional definitions
- Any desired cut-offs can be used with any chart
- CDC uses percentile cut-offs suggested by expert committees and/or used by federal programs
Crossing centiles

• **Height-for-age:**
  – more “falling off” between 0-6mos. using WHO

• **Weight-for-age:**
  – more “falling off” between 0-6mos. using WHO
  – much more “falling off” between 6-12mos. Using CDC

• **BMI-for-age:**
  – more “falling off” between 24-30mos. Using WHO
  – more “excessive growth” for all ages (24-60mos) using CDC
Cut-offs for abnormal growth

<table>
<thead>
<tr>
<th></th>
<th>CDC 2000</th>
<th>WHO 2006</th>
</tr>
</thead>
<tbody>
<tr>
<td>Low</td>
<td>&lt;5th percentile (-1.645 z-score)</td>
<td>&lt;=-2 z-score (2.3rd percentile)</td>
</tr>
<tr>
<td>High</td>
<td>&gt;=95th percentile (1.645 z-score)</td>
<td>&gt;2 z-score (97.7th percentile)</td>
</tr>
</tbody>
</table>
Weight-for-age <5th percentile
Weight-for-length/height ≥95th percentile
Low length/height-for-age
Low weight-for-age

CDC Reference <5th %ile
WHO Reference <2.3rd %ile

Age in months

%
High weight-for-length/height

![Graph showing CDC Reference > 95th percentile and WHO Reference > 97.7th percentile over age in months.](image)
Weight for length-boys

97th
85th
50th
3rd
Outlying percentiles

CDC: The outermost percentiles that were smoothed were the 3rd and 97th percentiles. The modified LMS values were not calculated using any percentiles outside those limits (approximately equivalent to a z-score of +/- 1.88). Caution is urged when trying to generate percentiles beyond those limits using the CDC LMS values.
Length or stature for age

- At younger ages, WHO length for age has a slightly narrower distribution than the CDC length for age.
- At older ages, CDC length/stature for age percentiles are almost always slightly lower than the corresponding WHO percentiles.
- Suggests that at older ages the CDC sample is slightly shifted to the left relative to the WHO sample.
- Differences are slight.
Weight for age

• In early infancy (up to ~8 months), WHO weight for age percentiles are higher than the corresponding CDC percentiles.
• From 8 mo to ~30 months, CDC weight for age percentiles tend to be higher than the corresponding WHO percentiles.
• After ~30 months, the percentiles are almost identical on the two charts.
Body mass index for age

• The CDC BMI-for-age percentiles are higher than the corresponding WHO percentiles
• The differences become smaller with age
• The median and the 85\textsuperscript{th} percentile agree closely at the older ages
• Suggests that the WHO sample is slightly shifted to the left relative to the CDC sample
Weight for length/stature

- The CDC weight for length/stature percentiles are higher than the corresponding WHO percentiles
- The differences become smaller with age
- The median and the 85th percentile agree closely at the older ages
- Suggests that the WHO sample is slightly shifted to the left relative to the CDC sample
Why does it matter? – Defining obesity

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Heavy infant in Grand Junction denied health insurance

Frustrated parents of a big infant who is being denied insurance view the system as "absurd."

By Nancy Lofholm
The Denver Post

GRAND JUNCTION — Alex Lange is a chubby, dimpled, healthy and happy 4-month-old.

But in the cold, calculating numbered charts of insurance companies, he is fat. That’s why he is being turned down for health insurance. And that’s why he is a weighty symbol of a problem in the health care reform debate.

Insurance companies can turn down people with pre-existing conditions who aren’t covered in a group health care plan.

Alex’s pre-existing condition — "obesity" — makes him a financial risk.

- Birth weight: Boy, 8 ¼ lb
- Current size: 17 lb, 25”
  - At 4 months of age
  - Being breastfed
- At the 99th percentile for weight & height
- Applied for health insurance
- Rocky Mtn Health Plans
- Parents’ application denied because baby too “fat”
- For children, plan refuses coverage at ≥ 95th percentile (“obese”)
- Application accepted after Denver Post article appeared