Malnutrition, definition, causes, indicators for assessment from a « Public Nutrition » perspective

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Course objectives

• Understand the concept of malnutrition and linkages to food security and human development
• Realize the magnitude of the problem of malnutrition at global level
• Know the principal causes of malnutrition in resource-poor contexts
• Identify vulnerable groups
• Understand the key indicators for assessing under and overnutrition
• Know the most important population-based preventive strategies for fighting malnutrition and the indicators that are useful for monitoring their impact
• Be able to read critically reports on assessment of malnutrition
Outline of the course

• Introduction
• Part I: anthropometric indicators
• Part II: indicators of micronutrient deficiencies
• Part III: the nutrition transition and the obesity epidemic
• Part IV: Nutrition-sensitive interventions and programmes
Introduction
Why does nutrition matter?

• Why include nutrition in a Master curriculum on Human Development and Food Security?
• What is the relationship between food security and nutrition?
• Why does nutrition matter to human development?
• Where does nutrition feature in Sustainable Development Goals?
Why does nutrition matter?

• Is food insecurity related to nutrition?
  – Nutrition is in the definition of food insecurity

• Good nutrition is the basis of good health and human well-being
  – Therefore it is central to human development

• Poor nutrition
  – affects populations’ health, intellectual and physical capacities;
  – it is a cause of poverty;
  – it is often transmitted from one generation to the next
Nutrition and the SDGs

SDG2: End hunger, achieve food security and improved nutrition and promote sustainable agriculture
Definitions

Nutrition is the provision of adequate energy and nutrients (in terms of amount and mix and timeliness) to the cells to enable them to perform their physiological function (of growth, reproduction, defense, repair, etc).

Malnutrition is the result of a lack or an excess in the provision of energy and/or nutrients to the body (undernutrition or overweight/obesity)
Definitions (cont’d)

• Nutritional status is the state of the body in relation to nutrition:
  – Clinical, i.e. apparent signs of poor nutrition
  – Growth and development of the body: dimensions (anthropometric measures) such as weight and height
  – Composition of the body and biochemical parameters

• Dietary intake is separate from nutritional status
Issues with terminology

• Malnutrition refers to poor nutritional status
• Undernourishment* is an FAO concept: it is the number or proportion of persons whose energy consumption is less than their minimum energy needs
• “Malnourished” can refer to the state of malnutrition or to inadequate food intakes
• Hunger is defined as “a feeling of discomfort or weakness caused by lack of food, coupled with the desire to eat”

* Also designated as “chronic hunger”
Types of malnutrition

• Undernutrition:
  – Protein-energy malnutrition
  – Micronutrient deficiencies

• Overnutrition:
  – Overweight and obesity
  – Health consequences (diabetes, cardiovascular diseases)

• Co-existence of under and overnutrition: “double burden of malnutrition”
  – Obesity and PEM in the same family
  – Obesity and micronutrient deficiencies in the same individual

• Chronic and acute malnutrition
Different Types of Childhood Malnutrition

- Normal
- Wasted: Low weight for height
- Stunted: Low height for age
- Underweight: Low weight for age

Note that this illustration does not include Childhood overweight/obesity which are also forms of malnutrition.
Examples of stunted children

Children of the same age
Understanding child malnutrition

- Wasting means that the infant/child is thin: she/he has lost fat and muscle mass
- Stunting means that the infant/child is short in stature: she/he did not grow in length/height has he/she should have
- Underweight means that she/he weighs less than she/he should
- A child can be both wasted and stunted
Understanding child malnutrition

• Wasting is usually due to a recent lack of food or illness (infections) that prevents the child from eating or absorbing nutrients of foods

• Stunting is a long term process, often starting in utero which is due to the mother’s malnutrition, to food intake lacking quality (insufficient intake of essential micronutrients) and the repetition of episodes of common infections

• Overweight and obesity are due to excessive energy intake and lack of physical activity

*Note that overweight and obesity can co-exist with micronutrient deficiency and with stunting*
Wasted child (source TALC)

Obese boys
UNICEF conceptual model of causes of malnutrition & mortality

Malnutrition and mortality

Immediate causes

- Insufficient food intakes
- Illness

Intermediate causes

- Household food insecurity
- Inadequate caring for mothers and young children
- Inadequate environment and health system

Underlying causes

- Governmental and non-governmental institutions
- Potential resources
Comments on the UNICEF conceptual model

• The model is useful for understanding and distinguishing the causes of malnutrition: it distinguishes the short and long “routes” for fighting malnutrition

• The model doesn’t take into consideration overweight/obesity as a form of malnutrition or the double burden of malnutrition

• It is focused on child malnutrition while malnutrition can affect all ages, but the concept can be applied to other age groups
Impact of undernutrition on child mortality*

Undernutrition is rarely a direct cause of death. It is most often an underlying cause of death from common illnesses of which it increases the occurrence and severity: approx. 45% of mortality due to common illnesses is attributed to malnutrition. Most deaths occur in moderately malnourished children.

* Among infants and children under five years, excluding neo-natal mortality
Nutrition throughout the life-cycle

Example: The life-cycle approach applied to micronutrient deficiency
The concept of the « 1000 days » window of opportunity

- Undernutrition often starts in utero when mothers are malnourished and/or stunted: intra-uterine growth retardation
- Undernutrition impairs physical growth and cognitive development
- After the age of 2 years damage is usually irreversible
- Therefore it is crucial to fight malnutrition during pregnancy and the first 2 years of the child, i.e. the 1000 days between conception and the child’s second birthday
- Many preventive interventions target this period of time (see SUN initiative)
Purpose of nutrition assessment at population level

- **What proportion** of the population is affected by malnutrition? how severely?
- **Who, Where** and **When** are population groups affected?
  - age, sex, socio-economic or occupational status etc;
  - is seasonality a factor?
- Is the problem **worsening or improving** (trends)?
- What are the **causes** of malnutrition?
- What **can be changed** to reduce the prevalence of malnutrition?
- Are **interventions efficient** to reduce the prevalence of malnutrition? (impact assessment)

*Note: While food insecurity is often assessed at household level, nutrition is defined at individual level*
Types of indicators of nutritional status

- Clinical indicators
  - Marasmus and Kwashiorkor (oedema)
  - Goiter
  - Xerophthalmia

- Anthropometric indicators (based on body measurements)

- Biochemical indicators

http://www.who.int/nutrition/nlis_interpretation_guide.pdf
Part I: Anthropometric measurements and indicators
Measurements, indices and indicators

• Measurements of body dimensions cannot be interpreted directly
• Indices have a biological interpretation:
  – e.g. height for age
  – they can be expressed in comparison to a reference population (standard deviation from the median of a reference population = standard)
• Indicators:
  – a cut-point for the index is defined, differentiating normal and at risk individuals
  – the indicator is the % of individuals below (or above) the cut-point
The most commonly used body measurements and indices derived

- Weight:
  - birth weight
  - weight for age
- Height:
  - height for age
  - weight for height
  - body mass index
- Mid upper arm circumference (MUAC)
- Waist circumference

On the basis of the indices, indicators are defined that correspond to a state of malnutrition
Infant and young child anthropometric indices and indicators of undernutrition

Wasting: low weight-for-height is a sign of acute malnutrition:
Indicator = prevalence of wasting

Stunting: low height-for-age is a sign of chronic malnutrition:
Indicator = prevalence of stunting

Underweight: low weight-for-age is a sign of acute or chronic malnutrition or both:
Indicator = prevalence of underweight
Underweight is an internationally recognized public health indicator for monitoring nutritional status and health in populations

MUAC is also used to assess acute malnutrition, especially in situations where it is difficult to weigh children
Measuring infants and young children

- Measurements need to be exact and precise
- Strict protocol for taking measurements
- Sources of error are many
- Imprecise age is a source of error
- Personnel needs to be skilled
- There exist standard tests for checking the skills of personnel at the start of a survey
- Some checks of the validity of the collected data are possible
How do we measure height/length?

Children under 2 years

- Child's backflat against longedge
- Child flat on board
- Hands cupped over ears; head against base of board
- Quadriceps and pelvis on support or floor or ground
- Line of sight perpendicular to face of board
- 90°

Children from 2 years

- Headpiece firmly on head
- Hand on chin
- Shoulders level
- Elbows, and arms at side
- Left hand on chest, fingers together against board
- Right hand on shin; hands against back and base of board
- Line of sight

Notes: How to Weigh and Measure Children: Assessing the Nutritional Status of Young Children, United Nations, 1985
How to weigh children?

Using a hanging scale

Using an electronic scale
For infants and young children indicators based on height and weight cannot be interpreted without sex*

- Sex of the infant/child is needed to interpret indices of height-for-age, weight-for-age and weight-for-height
- Precise age is needed for height-for-age, weight-for-age*
- Age is not needed for weight-for-height

* If the child doesn’t have a valid birth certificate an historical calendar will be used to identify the date of birth (see FAO guidelines for determining of age of infants and young children=
Mid-Upper Arm Circumference (MUAC) of children 6-60 months

In emergency situations use of the 3 colored tape:
Red under 115 mm = severe acute malnutrition
Yellow from 115 to 124 mm = moderate
Green from 125 mm = normal

See: http://www.unicef.org/nutrition/training/3.1.3/2.html

In non-emergency situations use standards by sex and age

Interpretation of anthropometric indices

- WHO has developed growth standards based on the growth of healthy adequately fed* infants and young children from several countries (2006)
- Normal growth is defined as the interval around the median and +/- 2 standard deviations of these children
- Weight and height of a child can be interpreted by comparison to the age/sex standard (i.e. calculation of the deviation from the median in standard deviations or z-scores)

*Exclusively breastfed until 6 months, inter alia

See: http://www.who.int/childgrowth/standards/en/
Height and weight at a given age in a healthy population follow a normal distribution. Height and weight for age of children surveyed can be described in terms of standard deviations from the median of the reference (healthy) population.

Height or weight for age less than -2 standard deviations from the reference median is considered as stunting or underweight.

Weight for height less than -2 sd from the reference defines wasting.

Weight for height of more than +2 sd defines overweight.
Height for age measured in a survey

Example of a stunted population: height for age is much lower than the reference

NB: standard deviation and z-score are synonymous
### Calculation of z-scores* and prevalence of undernutrition in a population

**WHO growth standards for infants and young children (WHO, 2006)**

Example: girls’ length for age from birth to 24 months of age (partial)

http://www.who.int/childgrowth/standards/en/

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In the reference population girls aged 9 months measure 70.1 cm on average (median length). The standard deviation (SD) or z-score of the median is 2.4 cm.

Girls with a length of less than -2 SD of the median, e.g. measuring less than 65.3 cm are considered stunted.

Prevalence of stunting at 9 months is the % of girls with a length of less than 65.3 cm.
Calculation of z-scores*(cont’d)

• For a particular child the z-score is:
  \[
  \text{z-score of the child} = \frac{\text{observed height} - \text{median of the standard}}{\text{z-score of the standard}}
  \]

• Example: the height of Adam, a boy aged 26 months, is 90 cm

• The median of the standard for boys of this age is 88.8 cm and the z-score is 3.2 cm

• The z-score of Adam is: \((90-88.8)/3.2=0.38\)
  
  Adam’s height is in the normal range

• If Adam’s height were less than -2 z-score of the median, he would be considered to be stunted

*NB : z-score and SD are synonymous
Calculation of z-scores and prevalence of undernutrition (cont’d)

• Example: Anna, a girl aged 13 months, measures 69.9 cm

• The median of the standard for girls of this age is 75.2 cm and the z-score is 2.6 cm

• What is Anna’s Z-score?

• Is she stunted?
Calculation of z-scores (cont’d)

- Solution: Anna’s length, a girl aged 13 months, is 69.9 cm
- The median of the standard for girls of this age is 75.2 cm and the z-score is 2.6 cm
- The z-score of Anna is: \( \frac{69.9 - 75.2}{2.6} = -2.04 \)
- Anna’s length is less than -2 z-score of the median, she is stunted
- The proportion or % of children who have a length/height for age less than -2 z-scores is the prevalence of stunting

Note: the same principle is used for weight for age and weight for height
A table of z-scores or the Anthro freeware can be used to obtain a child’s z-score
Presenting results of a survey as mean Z-scores: advantages

• The mean Z-score describes the nutritional status of the whole population
• Less prone to error than prevalence because less sensitive to outliers (due to measurement error)
• Value of the SD of the mean Z-score provides an indication of data quality (SDs of mean z-scores should be <1.3)

http://www.who.int/nutgrowthdb/about/introduction/en/index5.html
Type of malnutrition and severity

• Chronic versus acute malnutrition
  – Wasting is acute malnutrition
  – GAM (global acute malnutrition is wasting and/or oedema): GAM over 10% is an emergency (triggers an immediate intervention) or based on MUAC

• Severity of malnutrition: -2 to <-3 z-scores is moderate malnutrition, less than -3 is severe
  – Severe wasting
  – SAM (severe acute malnutrition): severe wasting and/or oedema
  – Severe stunting
Forms of severe acute malnutrition

Wasted child (marasmus)  
Child with Oedema (kwashiorkor)

*Note a child with Kwashiorkor can have a normal weight because of oedema*
Remarks on the difference between wasting and stunting

- Wasting is more easily detectable than stunting
- Wasting is the result of recent lack of food and illness while stunting develops over time, often starting during pregnancy
- Stunted mothers produce stunted babies
- Stunting has long term and permanent consequences on health and cognitive development
- Stunting is a cause and a consequence of poor human development
Conclusion on Stunting: indicator of poverty and loss of human capital potential

- Prevalence of stunting is highest amongst the poorest segments of the population
- Stunting is mostly irreversible after 2 years of life
- Economic impact of stunting:
  - Decreased school attendance and learning ability
  - Shorter adult height & lower income-earning capacity
  - Decreased offspring birth weight
  - Increased probability of transfer of poverty to next generation

High rates of stunting persist in sub Saharan Africa and parts of Asia (e.g. India)
Recognition of the importance of stunting for human development:
Stunting is included in SDG 2

The Millennium Development Goals did not refer to reduction of stunting.

Since then stunting has been recognized as an indicator of poverty.

Reduction of prevalence of childhood stunting marks success of sustainable actions to alleviate hunger and poverty.

Reducing stunting leads to higher levels of human development and economic growth.
Public health significance of prevalence levels of undernutrition in infants and young children (under five years of age)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Prevalence cut-off values for public health significance</th>
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| Underweight | < 10%: Low prevalence  
                         10-19%: Medium prevalence  
                         20-29%: High prevalence  
                         ≥ 30%: Very high prevalence |
| Stunting   | < 20%: Low prevalence  
                         20-29%: Medium prevalence  
                         30-39%: High prevalence  
                         ≥ 40%: Very high prevalence |
| Wasting    | < 5%: Acceptable  
                         5-9%: Poor  
                         10-14%: Serious  
                         ≥ 15%: Critical |

Prevalence of stunting in infants and young children <5 years

<table>
<thead>
<tr>
<th>Region</th>
<th>Prevalence 1990 (%)</th>
<th>Prevalence 2014 (%)</th>
<th>Numbers in 2014 (millions)</th>
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Note: Although reduction in % has been important in South East Asia it is still the continent with the highest number of stunted children.

Source: WHO Global health observatory data repository
Prevalence of stunting by country

Figure 2: Prevalence of stunting in children under 5 years

Source: Lancet series 2008
Prevalence of overweight/obesity in infants and young children <5 years*

<table>
<thead>
<tr>
<th>Region</th>
<th>Prevalence 1990 (%)</th>
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</table>

* Based on % of children with a weight-for-height of more than +2SD of the median WHO standard

Source: WHO Global health observatory data repository
Body Mass Index (BMI)

BMI is equal to weight in kg divided by height in meters squared:

\[ \text{BMI} = \frac{\text{Weight (kg)}}{(\text{Height (m)} \times \text{Height (m)})} \]

ADULTS: BMI standards for adult men and women (except pregnant women):

- Below 18.5 = Underweight
- 18.5 – 24.9 = Normal
- 25.0 – 29.9 = Overweight
- 30.0 and Above = Obese

INFANTS & CHILDREN: standards of BMI for age and sex


*Note: BMI norms do not depend on age and sex for adults while for all other age groups there is a standard for each age and sex group*
WHO BMI for age growth curve

**BMI-for-age GIRLS**
Birth to 2 years (z-scores)
Characteristics of a good indicator

• Validity: provides an exact measure of the phenomenon/variable of interest
• Has been validated in diverse contexts
• Specific of the variable of interest
• Sensitive to changes in the variable of interest
• Easy to measure and reproducible
• Relevant for the situation it is being used in:
  
  Certain indicators are useful in situations of crisis and others are more relevant outside of crisis
Data sources on anthropometric assessment

- WHO global database on child growth and malnutrition
  [http://www.who.int/nutgrowthdb/en/](http://www.who.int/nutgrowthdb/en/)
- Nutrition landscaping indicator guide:
  [http://www.who.int/nutrition/nlis_interpretation_guide.pdf](http://www.who.int/nutrition/nlis_interpretation_guide.pdf)
- Demographic and Health surveys (reports and statcompiler)