

Global burden of protein-energy malnutrition in the year 2000

1. Introduction

Protein-energy malnutrition is a nutritional deficiency resulting from either inadequate energy (caloric) or protein intake and manifesting in either marasmus or kwashiorkor. Marasmus is characterised by wasting of body tissues, particularly muscles and subcutaneous fat, and is usually a result of severe restrictions in energy intake. Kwashiorkor affects mainly children, is characterised by oedema (particularly ascites), and is usually the result of severe restrictions in protein intake. However, both types can be present simultaneously (marasmic kwashiorkor) and mask malnutrition due to the presence of oedema.

Malnutrition is often a synergistic factor underlying deaths in children in many developing countries but can also directly result in death.

Malnutrition may be followed by developmental disability of varying degree, including reduced physical and/or mental ability, often associated with reduced strength (measured as hand-grip strength), impaired cognitive function, reduced occupational activity¹⁻³.

2. Case and sequelae definitions

The case definition and sequelae used for protein-energy malnutrition are given in Table 1 below.

Table 1. Case and sequelae definitions for protein-energy malnutrition

| Cause category | GBD 2000 Code | ICD 9 codes | ICD 10 codes |
|-----------------------------|---------------|-------------|--------------|
| Protein-energy malnutrition | U054 | 260-263 | E40-46 |

| Sequela | Definition |
|--------------------------|---|
| Wasting | Observed weight for height at least 2 standard deviations below the mean for 0-5 year old children. |
| Stunting | Observed height for age at least 2 standard deviations below the mean for 0-5 year old children. |
| Developmental disability | Limited physical and mental ability to perform most activities in <u>all</u> of the following areas: recreation, education, procreation or occupation |

3. Disease model

Years lived with disability (YLDs) were calculated for the boxes shaded in grey.

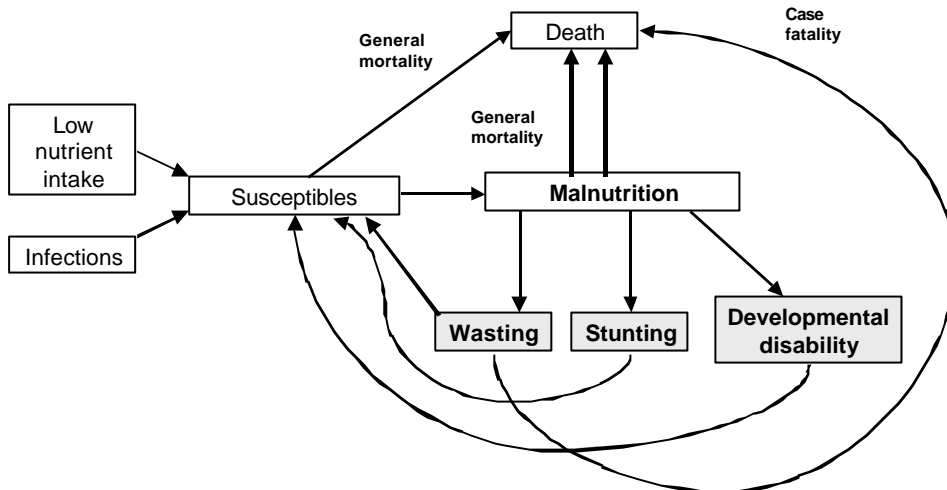


Figure 1. Protein-energy malnutrition disease model.

Table 2. Disease model assumptions

| | |
|----------------------|---|
| Definitions | As above |
| Incidence/Prevalence | Prevalence from nationally representative studies in NHD database (http://www.who.int/nutgrowthdb/) |
| Case fatality | 7.8% of all childhood deaths result from malnutrition, of which two thirds will be attributable to low birthweight, one third directly to malnutrition. |
| Other assumptions | Any degree of developmental disability is equal to the proportion of children who were underweight in pre-school years. Duration of wasting is on average 5 years, while stunting and developmental disability are permanent. Where country estimates were not available from the database, the <u>regional</u> average calculated from the available studies was used or data from other countries with similar epidemiological characteristics (details below). |
| Data | Community based, nationally representative prevalence studies on children available by country on NHD database (http://www.who.int/nutgrowthdb/) |

4. Disability weights and health state descriptions

Disability weights from the Global Burden of Disease 1990 study have been used.

Table 3. Disability weights

| Sequela/stage/severity level | Disability weight | Health state description |
|------------------------------|-------------------|---|
| Wasting | 0.053 | Thinness in children up to 5 years old |
| Stunting | 0.002 | Shortness of stature in children up to 5 years old |
| Developmental disability | 0.024 | Limited physical and mental ability to perform most activities in <u>all</u> of the following areas: recreation, education, procreation or occupation |

5. Epidemiological data

Epidemiological data from the WHO Global Database on Child Growth⁴ and Malnutrition (as listed above) were used to estimate prevalence of malnutrition for each country in the world. The method for compiling the database is described on the respective website (http://www.who.int/nutgrowthdb/intro_text.htm#Methods). This database contains recent nationally representative studies. Where country estimates were not available from the database, the regional average calculated from the available studies was used or data from other countries with similar epidemiological characteristics (details in table). Expert consultation within WHO resulted in the assumption that the duration of wasting is on average 5 years, while stunting and developmental disability are permanent.

In the calculation of YLDs it was assumed that any degree of developmental disability is equal to the proportion of children who were underweight in pre-school years⁵. Using the information on underweight from the database⁴, we estimated this proportion for each region.

It was assumed that 7.8% of all childhood deaths result from malnutrition, of which two thirds will be attributable to low birthweight, one third directly to malnutrition⁵.

A similar approach to estimating the burden of malnutrition was chosen for the GBD 1990⁵ but using a less comprehensive database of nationally representative studies.

Table 4. Data sources and assumptions - summary

| | |
|---------|---|
| AFRO D | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Equatorial Guinea, Gabon: Cameroon used; Gambia, Guinea Bissau: Senegal used; Sierra Leone: Liberia used; Somalia: Ethiopia used; Sudan: Regional average used. |
| AFRO E | NHD database used (http://www.who.int/nutgrowthdb/) |
| AMRO A | NHD database used (http://www.who.int/nutgrowthdb/) |
| AMRO B | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: St Vincent: St Lucia used; Suriname: Trinidad & Tobago used; |
| AMRO D | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Ecuador: Bolivia used. |
| EMRO B | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Cyprus: Greece used; Saudi Arabia (data not national): Oman used; UAE: Kuwait used. |
| EMRO D | NHD database used (http://www.who.int/nutgrowthdb/) |
| EURO A | NHD database used (http://www.who.int/nutgrowthdb/) only for Czech Republic and Croatia. No data for any other country, hence USA data used. |
| EURO B1 | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Bosnia & Herzegovina: Yugoslavia used; Bulgaria: Romania used; Poland, Slovakia: Czech Republic used. |
| EURO B2 | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Tajikistan: Average of 30 district studies used; Turkmenistan: Uzbekistan used. |
| EURO C | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Belarus, Estonia, Latvia, Lithuania, Moldova: Regional average used; Ukraine: Russian Federation used. |
| SEARO B | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Thailand, Malaysia, Brunei, Singapore: Philippines used; |
| SEARO D | NHD database used (http://www.who.int/nutgrowthdb/) |
| WPRO A | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: New Zealand: USA data used. |
| WPRO B1 | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: South Korea: District data used. |
| WPRO B2 | NHD database used (http://www.who.int/nutgrowthdb/) |
| WPRO B3 | NHD database used (http://www.who.int/nutgrowthdb/) with exception of: Marshall Islands, Nauru, Niue, Palao, Samoa, Cook Island, Tuvalu, Vanuatu, Micronesia: Regional average used. |

6. Incidence, prevalence and mortality estimates for 2000

Table 5. Age-standardized incidence of stunting, wasting and developmental disability, for WHO epidemiological subregions, 2000.

| Subregion | Stunting | | Wasting | | Developmental disability | |
|-----------|----------------------------|---------|----------------------------|---------|----------------------------|---------|
| | Age-std. Incidence/100,000 | | Age-std. Incidence/100,000 | | Age-std. Incidence/100,000 | |
| | Males | Females | Males | Females | Males | Females |
| AFRO D | 630.1 | 630.1 | 240.2 | 240.2 | 199.8 | 199.8 |
| AFRO E | 735.7 | 735.7 | 121.4 | 121.4 | 183.9 | 183.9 |
| AMRO A | 40.5 | 40.5 | 11.4 | 11.4 | 2.6 | 2.6 |
| AMRO B | 176.0 | 176.0 | 36.1 | 36.1 | 28.7 | 28.7 |
| AMRO D | 515.7 | 515.7 | 42.2 | 42.2 | 28.7 | 28.7 |
| EMRO B | 213.0 | 213.0 | 111.8 | 112.6 | 28.7 | 28.7 |
| EMRO D | 503.4 | 213.0 | 101.2 | 101.2 | 151.4 | 151.4 |
| EURO A | 40.5 | 40.5 | 13.2 | 13.2 | 2.6 | 2.6 |
| EURO B1 | 146.1 | 146.1 | 37.8 | 37.8 | 19.4 | 19.4 |
| EURO B2 | 482.2 | 482.2 | 165.4 | 165.4 | 28.7 | 28.7 |
| EURO C | 151.4 | 151.4 | 60.7 | 60.7 | 19.4 | 19.4 |
| SEARO B | 478.7 | 478.7 | 182.2 | 182.2 | 121.4 | 121.4 |
| SEARO D | 770.9 | 770.9 | 264.0 | 264.0 | 131.1 | 131.1 |
| WPRO A | 40.5 | 40.5 | 11.4 | 11.4 | 2.6 | 2.6 |
| WPRO B1 | 406.6 | 406.6 | 64.2 | 64.2 | 66.6 | 66.6 |
| WPRO B2 | 665.3 | 665.3 | 169.8 | 169.8 | 261.4 | 261.4 |
| WPRO B3 | 311.5 | 311.5 | 104.7 | 104.7 | 90.6 | 90.6 |
| World | 508.1 | 500.4 | 145.6 | 146.2 | 105.8 | 106.6 |

- Age-standardized to World Standard Population⁶.

Table 6. Age-standardized prevalence of stunting, wasting and developmental disability, for WHO epidemiological subregions, 2000.

| Subregion | Stunting | | Wasting | | Developmental disability | |
|-----------|-----------------------------|---------|-----------------------------|---------|-----------------------------|---------|
| | Age-std. prevalence/100,000 | | Age-std. prevalence/100,000 | | Age-std. prevalence/100,000 | |
| | Males | Females | Males | Females | Males | Females |
| AFRO D | 3150.4 | 3150.4 | 1199.8 | 1201.2 | 11043.4 | 11043.4 |
| AFRO E | 3678.4 | 3678.4 | 605.4 | 605.4 | 10167.2 | 10167.2 |
| AMRO A | 202.4 | 202.4 | 56.3 | 56.3 | 139.1 | 139.1 |
| AMRO B | 888.8 | 888.8 | 182.2 | 182.2 | 1585.6 | 1585.6 |
| AMRO D | 2578.4 | 2578.4 | 212.1 | 212.1 | 1585.6 | 1585.6 |
| EMRO B | 1064.8 | 1064.8 | 559.7 | 561.4 | 1585.6 | 1585.6 |
| EMRO D | 2516.8 | 1064.8 | 507.8 | 508.6 | 7162.9 | 7162.9 |
| EURO A | 202.4 | 202.4 | 64.2 | 64.2 | 139.1 | 139.1 |
| EURO B1 | 730.4 | 730.4 | 191.0 | 191.0 | 1071.0 | 1071.0 |
| EURO B2 | 2411.2 | 2411.2 | 826.3 | 826.3 | 1585.6 | 1585.6 |
| EURO C | 756.8 | 756.8 | 302.7 | 302.7 | 1071.0 | 1071.0 |
| SEARO B | 2393.6 | 2393.6 | 912.6 | 912.6 | 6717.8 | 6717.8 |
| SEARO D | 3854.4 | 3854.4 | 1320.9 | 1320.9 | 7274.2 | 7274.2 |
| WPRO A | 202.4 | 202.4 | 59.0 | 59.0 | 139.1 | 139.1 |
| WPRO B1 | 2032.8 | 2032.8 | 319.4 | 320.3 | 3685.8 | 3685.8 |
| WPRO B2 | 3326.4 | 3326.4 | 849.2 | 848.3 | 14464.9 | 14464.9 |

| | | | | | | |
|---------|--------|--------|-------|-------|--------|--------|
| WPRO B3 | 1557.6 | 1557.6 | 521.8 | 522.7 | 5007.1 | 5007.1 |
| World | 2541.2 | 2502.7 | 727.8 | 731.2 | 4753.3 | 4740.2 |

- Age-standardized to World Standard Population⁶.
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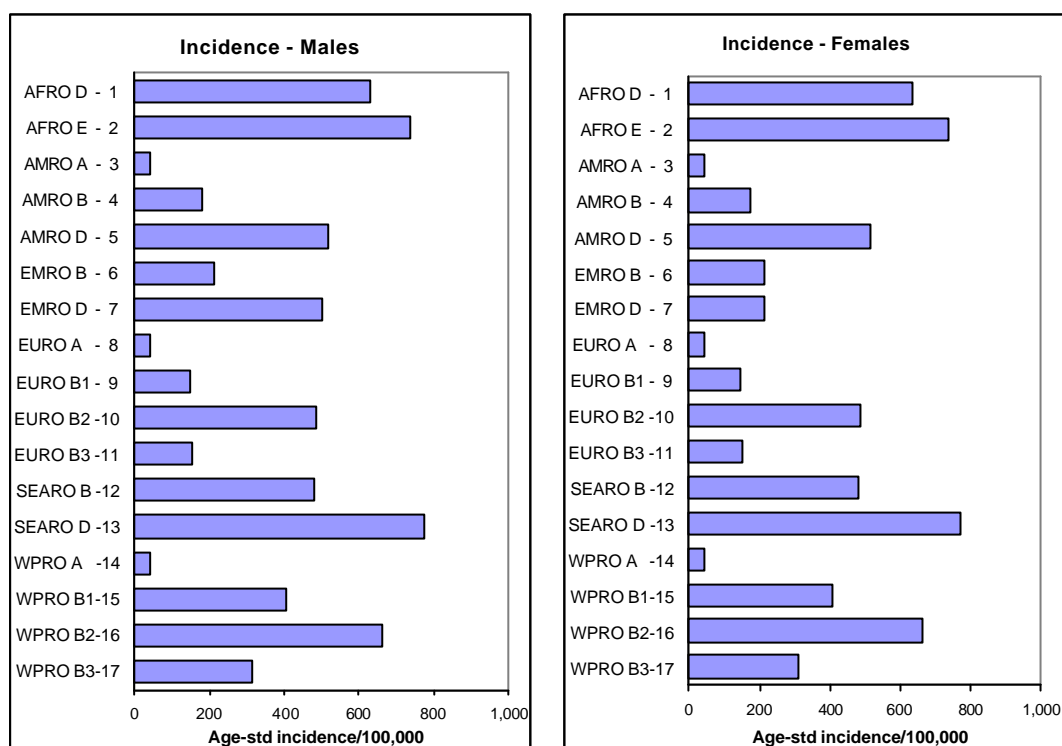


Figure 2. Age-standardized stunting incidence rate estimates, WHO epidemiological subregions, by sex, 2000.

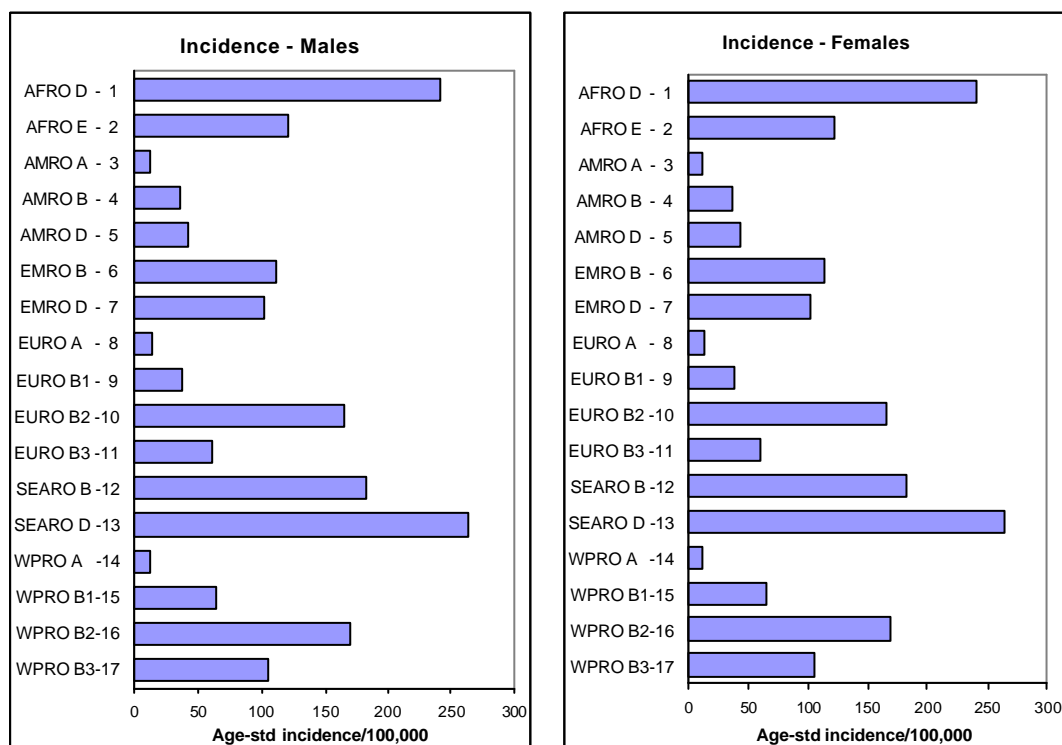


Figure 3. Age-standardized wasting incidence rate estimates, WHO epidemiological subregions, by sex, 2000.

7. Global burden of protein-energy malnutrition in 2000

General methods used for the estimation of the global burden of disease are given elsewhere⁷. The tables and graphs below summarise the global burden of PEM estimates for the GBD 2000 and compare them with the protein-energy malnutrition estimates from the GBD 1990⁸.

Table 7. Global total YLD, YLL and DALY estimates, 1990 and 2000.

| | <i>Males</i> | <i>Females</i> | <i>Persons</i> |
|-------------------|--------------|----------------|----------------|
| YLD('000) | | | |
| <i>GBD1990</i> | 5,006 | 4,871 | 9,878 |
| <i>GBD2000</i> | 4,850 | 4,608 | 9,459 |
| YLL('000) | | | |
| <i>GBD1990</i> | 5,329 | 5,750 | 11,080 |
| <i>GBD2000</i> | 3,447 | 3,577 | 7,025 |
| DALY('000) | | | |
| <i>GBD1990</i> | 10,336 | 10,621 | 20,957 |
| <i>GBD2000</i> | 8,298 | 8,185 | 16,483 |

Table 8. YLD, YLL and DALY estimates for WHO epidemiological subregions, 2000.

| Subregion | YLD/100,000 | | YLL/100,000 | | YLD | YLL | DALY |
|------------------|--------------------|----------------|--------------------|----------------|---------------|---------------|---------------|
| | Males | Females | Males | Females | ('000) | ('000) | ('000) |
| AFRO D | 435 | 426 | 462 | 386 | 1,437 | 1,410 | 2,844 |
| AFRO E | 381 | 373 | 503 | 467 | 1,272 | 1,662 | 2,928 |
| AMRO A | 5 | 5 | 4 | 6 | 15 | 15 | 30 |
| AMRO B | 48 | 46 | 135 | 120 | 209 | 571 | 777 |
| AMRO D | 94 | 90 | 239 | 252 | 66 | 178 | 242 |
| EMRO B | 72 | 74 | 34 | 74 | 101 | 75 | 177 |
| EMRO D | 262 | 230 | 51 | 55 | 340 | 74 | 417 |
| EURO A | 4 | 4 | 2 | 2 | 17 | 9 | 25 |
| EURO B1 | 26 | 25 | 22 | 20 | 43 | 36 | 78 |
| EURO B2 | 107 | 102 | 51 | 32 | 53 | 21 | 74 |
| EURO C | 22 | 19 | 7 | 3 | 49 | 12 | 61 |
| SEARO B | 191 | 170 | 67 | 65 | 711 | 263 | 975 |
| SEARO D | 265 | 268 | 140 | 171 | 3,593 | 2,000 | 5,598 |
| WPRO A | 4 | 4 | 6 | 3 | 6 | 7 | 12 |
| WPRO B1 | 80 | 76 | 29 | 48 | 1,059 | 531 | 1,592 |
| WPRO B2 | 345 | 326 | 87 | 98 | 477 | 133 | 612 |
| WPRO C | 168 | 169 | 392 | 411 | 12 | 28 | 39 |
| World | 159 | 154 | 114 | 119 | 9,459 | 7,025 | 16,483 |

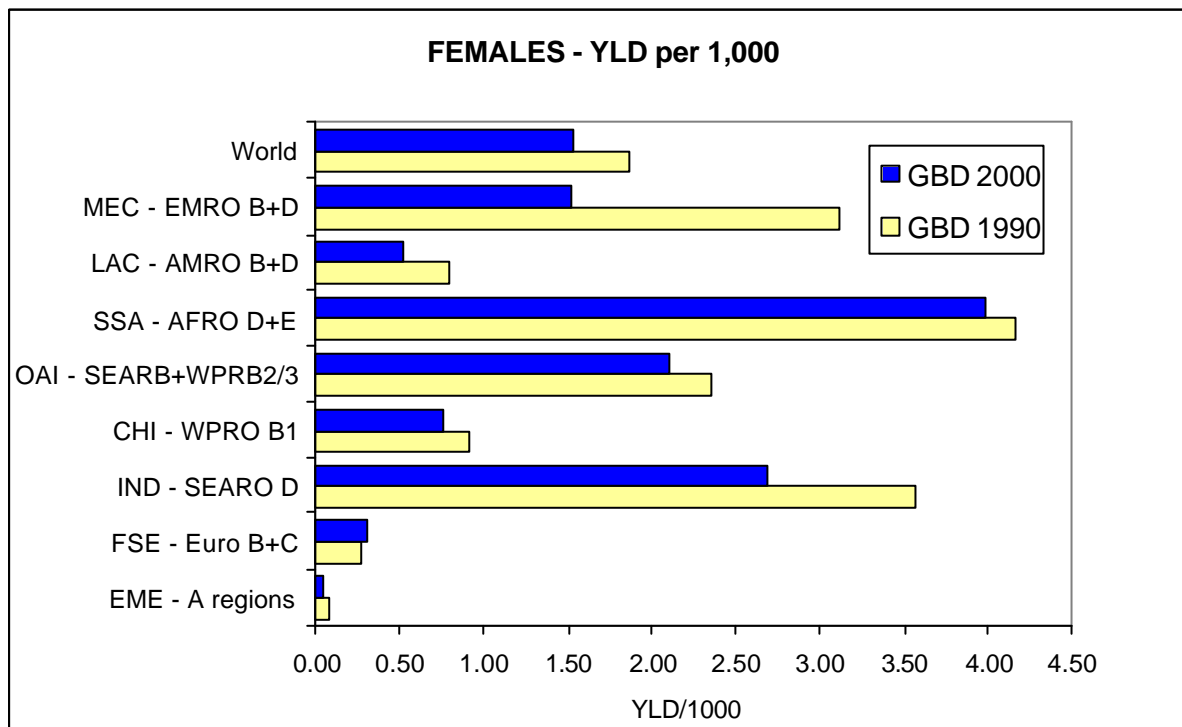
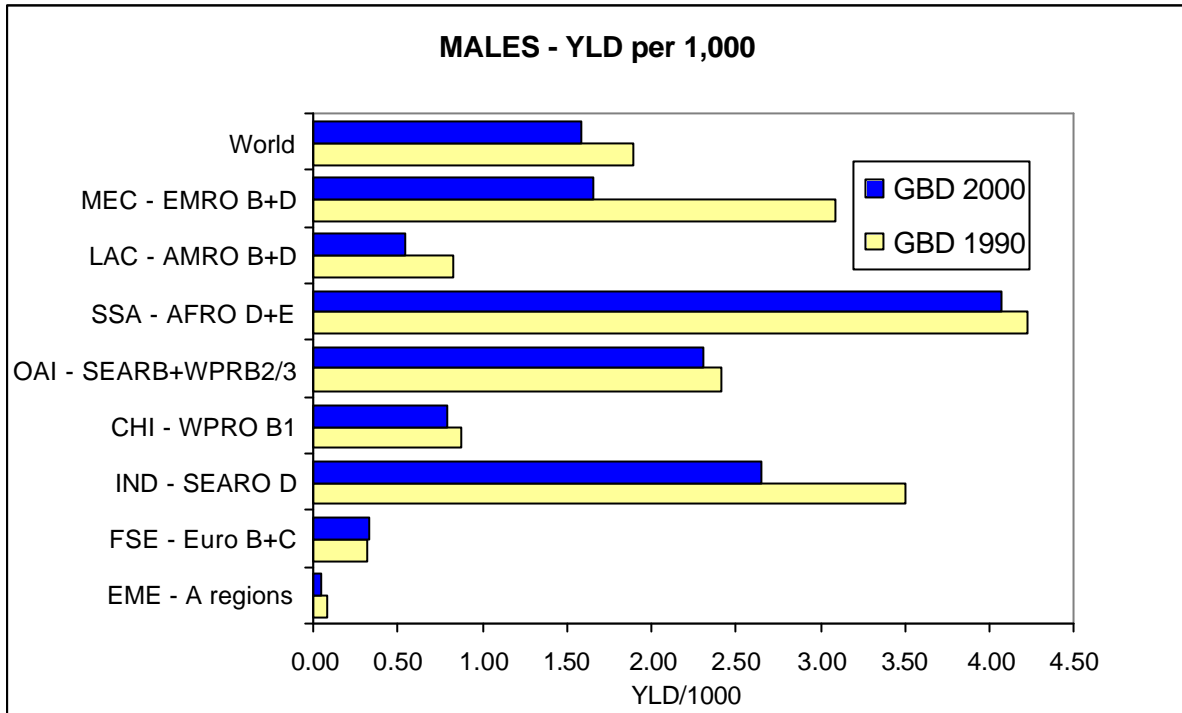


Figure 4. Total YLD rates, by sex, broad regions, 1990 and 2000.

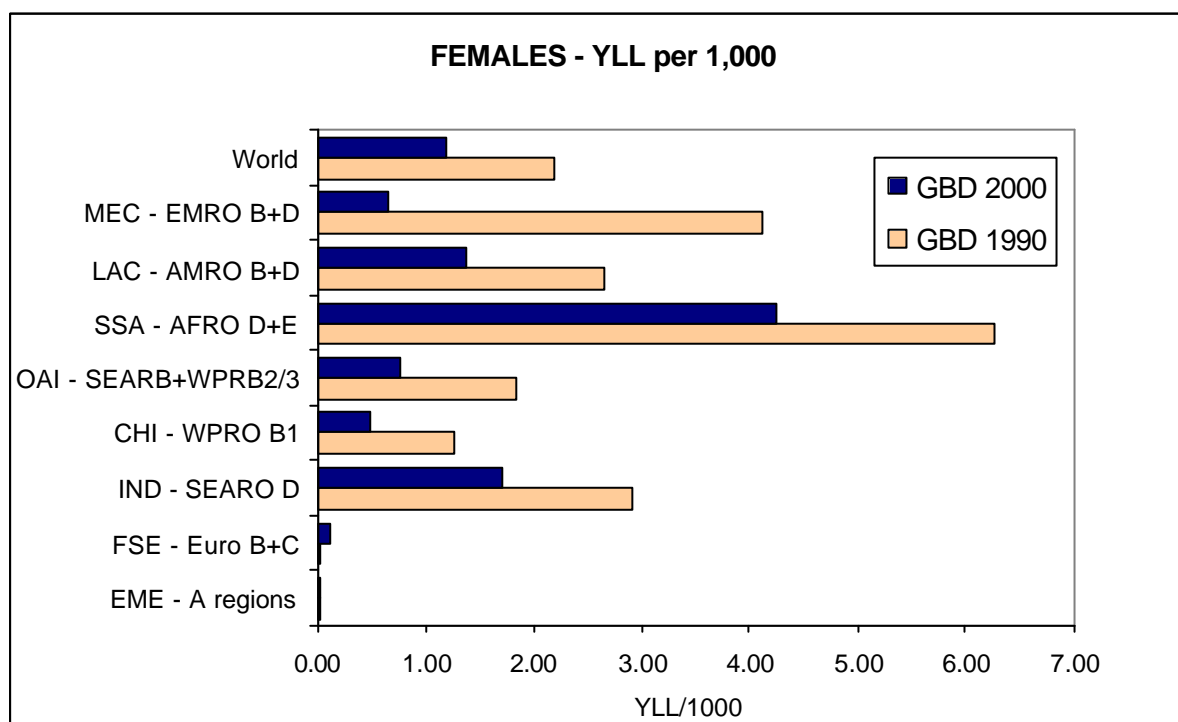
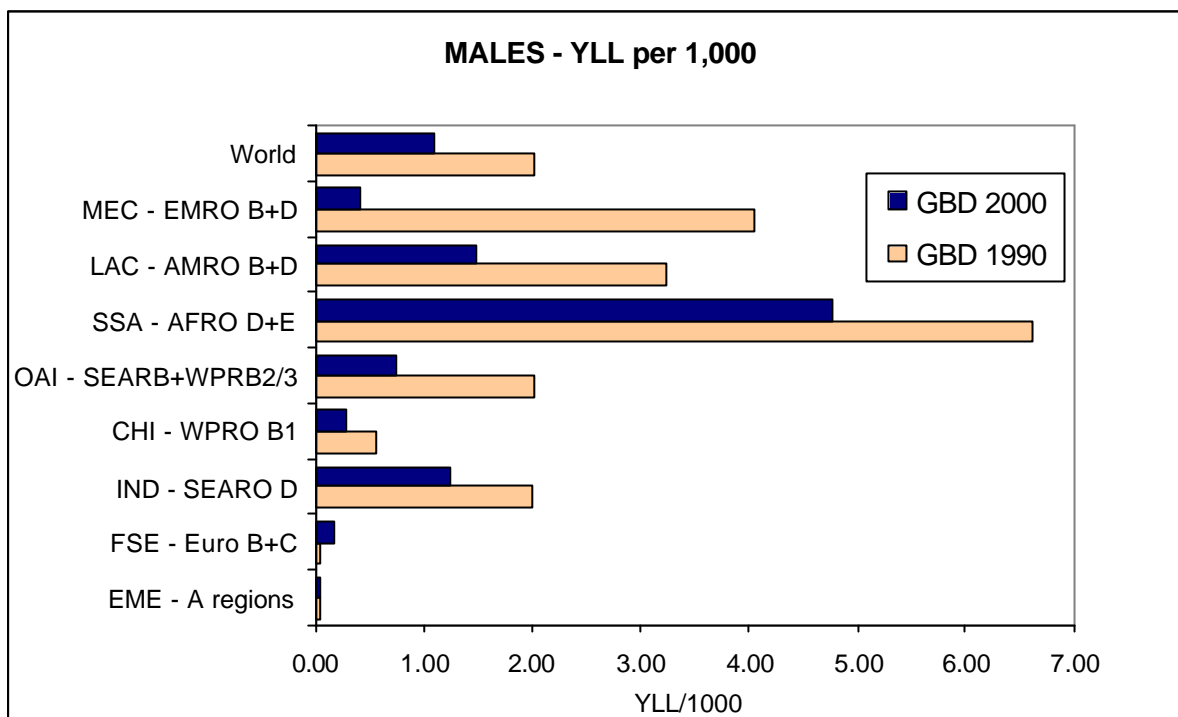


Figure 5. Total YLL rates, by sex, broad regions, 1990 and 2000.

8. Uncertainty analysis

General methods for uncertainty analysis of estimates for the Global Burden of Disease 2000 are outlined elsewhere⁹. Uncertainty estimates for protein-energy malnutrition sequelae are shown in Table 9.

Table 9. Uncertainty in stunting, wasting and developmental disability prevalence estimates, for WHO epidemiological subregions, 2000.

| Subregion | Stunting prevalence per 1000 | | Wasting prevalence per 1000 | | Developmental disability prevalence per 1000 | |
|-----------|--------------------------------|--------------------|-----------------------------|--------------------|--|--------------------|
| | Truncated normal distribution* | | Lognormal distribution | | Lognormal distribution | |
| | Mean | Standard deviation | Mean | Standard deviation | Mean | Standard deviation |
| AFRO D | 58.5 | 25.0 | 22.4 | 10.0 | 107.8 | 40.0 |
| AFRO E | 70.7 | 30.0 | 10.7 | 5.0 | 99.1 | 40.0 |
| AMRO A | 1.5 | 0.7 | 0.5 | 0.2 | 1.4 | 0.6 |
| AMRO B | 10.4 | 4.5 | 2.2 | 1.0 | 15.8 | 7.0 |
| AMRO D | 38.5 | 15.0 | 3.4 | 1.5 | 15.6 | 7.0 |
| EMRO B | 14.2 | 6.5 | 7.5 | 2.5 | 15.7 | 7.0 |
| EMRO D | 38.2 | 15.0 | 7.7 | 2.7 | 70.6 | 30.0 |
| EURO A | 1.2 | 0.5 | 0.4 | 0.2 | 1.1 | 0.4 |
| EURO B1 | 6.0 | 2.5 | 1.6 | 0.7 | 10.8 | 5.0 |
| EURO B2 | 31.5 | 14.0 | 11.0 | 5.0 | 15.7 | 7.0 |
| EURO C | 4.4 | 2.0 | 1.8 | 0.8 | 10.8 | 5.0 |
| SEARO B | 28.4 | 13.0 | 10.8 | 5.0 | 66.5 | 28.0 |
| SEARO D | 52.7 | 23.0 | 18.5 | 8.0 | 72.0 | 30.0 |
| WPRO A | 1.2 | 0.5 | 0.4 | 0.1 | 1.4 | 0.7 |
| WPRO B1 | 17.5 | 7.5 | 2.7 | 1.2 | 37.0 | 15.0 |
| WPRO B2 | 40.0 | 18.0 | 10.2 | 5.0 | 144.0 | 65.0 |
| WPRO C | 24.3 | 11.0 | 8.2 | 3.8 | 49.3 | 20.0 |

* Truncated at zero and 1000.

9. Conclusions

These are version 2 estimates for the GBD 2000. Apart from the uncertainty analysis, updating estimates to reflect revisions of mortality estimates and any new or revised epidemiological data or evidence, it is not intended to undertake any major addition revision of these estimates.

We welcome comments and criticisms of these draft estimates, and information on additional sources of data and evidence. Please contact Claudia Stein (EBD/GPE) on email steinc@who.int.

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10. References

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