BMC
Pediatrics

# Child undernutrition in Kenya: trend analyses from 1993 to 2008–09

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## Abstract

**Background:** Research on trends in child undernutrition in Kenya has been hindered by the challenges of changing criteria for classifying undernutrition, and an emphasis in the literature on international comparisons of countries' situations. There has been little attention to within-country trend analyses. This paper presents child undernutrition trend analyses from 1993 to 2008–09, using the 2006 WHO criteria for undernutrition. The analyses are decomposed by child's sex and age, and by maternal education level, household Wealth Index, and province, to reveal any departures from the overall national trends.

**Methods:** The study uses the Kenya Demographic and Health Survey data collected from women aged 15–49 years and children aged 0–35 months in 1993, 1998, 2003 and 2008–09. Logistic regression was used to test trends.

**Results:** The prevalence of wasting for boys and girls combined remained stable at the national level but declined significantly among girls aged 0–35 months (p < 0.05). While stunting prevalence remained stagnant generally, the trend for boys aged 0–35 months significantly decreased and that for girls aged 12–23 months significantly increased (p < 0.05). The pattern for underweight in most socio-demographic groups showed a decline.

**Conclusion:** The national trends in childhood undernutrition in Kenya showed significant declines in underweight while trends in wasting and stunting were stagnant. Analyses disaggregated by demographic and socio-economic segments revealed some significant departures from these overall trends, some improving and some worsening. These findings support the importance of conducting trend analyses at detailed levels within countries, to inform the development of better-targeted childcare and feeding interventions.

**Keywords:** Undernutrition, Wasting, Stunting, Underweight, Trends, Demographic and Health Survey, Kenya

## Background

Worldwide, about 2.2 million children die annually, with poor nutritional status as an underlying cause [1]. Global statistics for surviving undernourished children indicate that approximately 171 million children are chronically undernourished (stunted), 60 million are acutely undernourished (wasted), and 100 million are underweight [2]. Undernutrition is not only linked to child mortality but also to poor functional development of the child. Undernourished children are highly susceptible to common childhood ailments like diarrhea, respiratory infections and worm infestations. Recurrence of such ailments falters a child's physical, behavioral, motor and cognitive development, and also compromises her/his health and

functioning in adulthood [3]. Combatting child undernutrition is obviously crucial, and its complexity makes it hard to tackle. It results not only from macronutrient deficiencies (protein, fat and carbohydrate) but also from micronutrient deficiencies (trace minerals and vitamins), among which zinc deficiency is particularly deleterious to children's normal growth [4]. Therefore, different aspects of food deprivation (quantity, quality and food group diversity) lead to different manifestations of undernutrition (wasting, stunting and underweight). Consequently, child undernutrition is a multidimensional problem that defies simple solutions. There is a fundamental need to better understand the public health dimensions of the problem, to provide a foundation for precisely targeted interventions in local contexts.

The burden of child undernutrition is unsurprisingly greatest in the world's poorest countries, especially in

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sub-Saharan Africa and Asia [5]. This is a highly salient issue in Kenya, which is among the 20 countries that account for 80% of the world's chronically undernourished children [6]. The most recent Kenyan national prevalence estimates are 35% for stunting, 7% for wasting and 16% for underweight [7,8].

A child who experiences a chronic shortage of appropriate types and quantities of food is likely to grow in height/length more slowly than expected for children of the same sex and age. Such a shortfall in growth, termed 'stunting', is a classical indicator of underlying child undernutrition. A child who experiences acute food shortage and/or infection is likely to gain weight more slowly than expected for children of the same sex and height/length. Such a shortfall in growth is termed 'wasting', which is also a classical indicator of underlying undernutrition. Underweight is a composite indicator of stunting and wasting and thus an overall indicator of the extent of child undernutrition [9,10]. Underweight however is not a very useful indicator for interventions as it does not differentiate the extent of stunting and wasting.

According to the World Health Organisation (WHO) 2006 classification of child undernutrition, children with a Z-score below –2 Standard Deviations (SD) of the median for weight-for-height/length (WHZ) or (WLZ), height/length-for-age (HAZ) or (LAZ) and weight-for-age (WAZ) are classified as wasted, stunted and underweight respectively. Children with a Z-score below –3 SD of the median are classified as severely undernourished, while those with a Z-score between –2 SD and –3 SD are classified as being moderately undernourished. Those with a Z-score between –1 SD and –2 SD are classified as mildly undernourished [9].

There is a tendency in the literature to define and describe child undernutrition at an aggregate level, for example by reporting national prevalence for all children ages 0–59 months, without differentiation by age, sex and other factors. Yet, important differentiations do exist for specific demographic and socio-economic segments in the under-five population and nutrition interventions are correspondingly specific. In sub-Saharan Africa, boys have consistently posted higher rates of stunting compared to girls [11]. Many (sometimes contradicting) reasons have been hypothesized to explain the sex difference, such as gender-differentiated feeding practices [12,13]. It is also postulated that girls are physically less active and therefore spend less energy compared to boys, and that boys are more vulnerable to acute respiratory infection and diarrhoea [14].

Undernutrition is most critical during the first two years of life, especially stunting, after which it is difficult to restore normal growth [15]. During this early period, poor infant and young nutrition and care practices coupled with infectious diseases increase the probability of child undernutrition [16]. Studies conducted in developing countries indicate that exclusive breastfeeding is not common, with complementary foods introduced very early [17,18]. This leads to faltering child growth [19].

Level of maternal education has been documented as a determining factor in child undernutrition. In an environment with sufficient resources, mothers with education are more likely to utilize modern health care and have good health care knowledge and reproductive behaviours [20,21]. Maternal education does not, however, automatically impart nutrition knowledge, and thus mothers with education may still have undernourished children.

Given this background, it cannot be assumed that international or national trends reflect sub-group trends with validity; it is an empirical question requiring appropriate sub-group analyses. This study therefore aimed to describe time trends in child undernutrition prevalence in Kenya, with overall trends decomposed by age, province[a], urban/rural residence, maternal education level and Wealth Index (WI), for boys and girls separately. Previous studies which have examined sub-groups in Kenya are inadequate for today's needs for one or more of these reasons: the design was a single cross-sectional survey and therefore not useful to define trends over time; the study sample was not nationally representative data; the study was conducted before 2006 and hence used outdated reference standards for child growth [17,22-26].

The present study addresses these limitations, by undertaking trend analyses of stunting, wasting and underweight, in defined sub-groups in Kenya, and using the 2006 WHO child growth standards in the analysis of data collected from four cross-sectional surveys conducted in 1993, 1998, 2003 and 2008–09. The surveys used identical methods, making their results comparable.

## Methods
### Data
This study used data from the Kenya Demographic and Health Survey (KDHS), a series of national cross-sectional surveys conducted in 1993, 1998, 2003 and 2008–09 (data from KDHS earlier than 1993 are not used). These datasets are publicly accessible through application to MEASURE DHS[b] [26]. In all survey years, data were collected using identical questionnaire items for women of reproductive age 15–49 years old. In all four surveys, a standard child anthropometry protocol was used. Children 0–59 months were weighed using scales fitted with a digital screen and measured for height using a measuring board. Weight was recorded in kilograms and height/length in centimeters. Children younger than 24 months were measured lying down on the board (recumbent length), while standing height was recorded for older children. Extensive information on data collection and management has been published elsewhere [7,27-30].

Table 1 shows the two-stage sampling design used by the Kenya Demographic and Health Survey. The first stage involved selecting data collection points (clusters) from the national master sample frame and then households were systematically sampled from the selected clusters with women of ages 15–49 years eligible for interview [7,27-29].

To enable a trend analysis, variables of interest were identified in the base year data file (1993). Thereafter, data files were sorted by their identification variables and the four cross-sectional datasets of 1993, 1998, 2003 and 2008–09 were merged into a single data file. Besides examining trends for the samples as wholes, sub-group analyses were undertaken, separately for boys and girls, by age, province, residence, maternal education and WI. In each trend analysis, logistic regression was used to test the null hypothesis that the regression coefficient $\beta$ for survey year was not significantly different from zero, using the equation:

$$log(p/1-p) = \beta_0 + \beta_{survey\ year} \cdot survey\ year$$

Due to lack of anthropometry data for children older than 36 months in the 1998 survey, the analysis reported in this paper was restricted to children aged 0–35 months. This allowed comparability of trends across the four surveys from 1993 to 2009. The age categories analyzed were 0–5 months, 6–11 months, 12–23 months and 24–35 months. During the 1993 and 1998 survey years, KDHS did not collect data in North-Eastern province. Consequently, North-Eastern province was excluded in the analysis in order to allow comparison of prevalence across all the four survey years. Provinces included in the analysis include Nairobi, Central, Coast, Eastern, Nyanza, Rift-Valley and Western.

Self-reported maternal education level was categorized as no education, incomplete primary, complete primary and incomplete secondary education. Sample size limitations in the 1993 survey for the higher education category were overcome by combining the complete secondary education and higher education categories in the analyses presented in this paper.

Standard of living measurement involved classification of children into quintiles based on the household Wealth Index. This is a proxy for standard of living based on household ownership of assets and housing quality. Each asset is assigned a factor score generated through principal component analysis, with the scores summed and standardized. All individuals are assigned the score and the quintile (poorest, poorer, middle, richer and richest) of their household [31].

### Child anthropometry

In assessing children's nutritional status, wasting (low weight-for-length/height), stunting (low length/height-for-age) and underweight (low weight-for-age) were used as the three indicators of child undernutrition. In conformity with the recommended World Health Organization (WHO) child growth standards of 2006, the SPSS syntax file 'igrowup_DHSind.sps' was used to calculate Z-scores for the three anthropometric indicators. Children were considered wasted, stunted or underweight if their WHZ/WLZ, HAZ/LAZ and WAZ score was less than –2 SD respectively. Extreme Z-scores considered to be biologically implausible were flagged and not used in the analysis if WHZ/WLZ score was less than –5 SD or greater than 5 SD, HAZ/LAZ score was less than –6 SD or greater than 6 SD and WAZ score was less than –6 SD or greater than 5 SD [32,33].

### Analysis

SPSS for windows version 19 was used to conduct the analyses. The design effect parameters 'sampling weight', 'sample domain' and 'sample cluster' [32] were incorporated using SPSS' Complex Samples Module. In line with recommendations that emphasize provision of levels of uncertainty in the estimates of undernutrition [33], 95% confidence intervals (C.I.) for the prevalence estimates were computed and are presented in Tables 2, 3, 4. Logistic regression was used to test trends. This involved modeling change in undernutrition prevalence regressed on time (the four survey years) with probability values for Wald F tests less than 0.05 considered significant (Tables 2, 3, 4). It is important to note that in the Tables, the 95% C.I. are calculated separately for each prevalence estimate and are not associated with the Wald F statistics that were generated by the logistic regression tests for trends.

### Results

#### Description of the study samples

Table 5 shows the sample distributions for each year by child's growth, sex and age, and by province, urban/rural residence, maternal education and Wealth Index. Sample sizes in the various socio-demographic groups varied considerably, affecting the comparability of the Wald F Statistics generated by logistic regression in the tests of trends (shown in Tables 2, 3, 4). This variability should be kept in mind in the examination of the data in Tables 2, 3, 4.

### Table 1 Sampling design, KDHS

|  | 1993 | 1998 | 2003 | 2008-09 |
|---|---|---|---|---|
| Clusters Selected | 536 | 536 | 400 | 400 |
| Households Selected | 8805 | 9465 | 9865 | 9936 |
| Women Interviewed | 7540 | 7881 | 8195 | 8444 |
| Response Rate | 95% | 96% | 94% | 96% |

**Table 2 Wasting trends by age, province, residence, maternal education and wealth index, KDHS**

|  |  | 1993 | | | 1998 | | | 2003 | | | 2008-09 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
|  | Sex | n | % | C.I. | n | % | C.I. | n | % | C.I. | n | % | C.I. | Wald F | P-value | Trend |
| **Total** | M/F | 2,969 | 8.4 | 7.2-9.8 | 2,921 | 8.7 | 7.6-10.0 | 3,020 | 7.2 | 6.0-8.5 | 3,028 | 7.4 | 6.1-8.9 | 2.206 | 0.138 | |
|  | M | 1,789 | 9.1 | 7.5-10.9 | 1,501 | 9.2 | 7.7-10.9 | 1,818 | 8.6 | 7.0-10.5 | 1,807 | 8.6 | 7.0-10.5 | 0.259 | 0.611 | |
|  | F | 1,180 | 7.3 | 5.8-9.3 | 1,420 | 8.2 | 6.7-10.1 | 1,202 | 5.0 | 3.8-6.5 | 1,221 | 5.6 | 4.3-7.4 | 5.338 | 0.021 | ↘ |
| **Age** | | | | | | | | | | | | | | | | |
| 0-5 months | M | 275 | 9.7 | 6.3-14.7 | 273 | 9.9 | 6.5-14.6 | 342 | 10.0 | 6.9-14.4 | 308 | 8.0 | 5.2-12.2 | 0.293 | 0.589 | |
|  | F | 160 | 8.3 | 4.8-14.1 | 179 | 8.6 | 5.0-14.4 | 170 | 5.6 | 2.9-10.6 | 142 | 12.8 | 7.8-20.2 | 0.391 | 0.532 | |
| 6-11 months | M | 367 | 10.4 | 7.3-14.6 | 293 | 14.9 | 10.4-20.9 | 366 | 10.0 | 7.1-13.9 | 373 | 13.2 | 8.1-20.8 | 0.104 | 0.747 | |
|  | F | 179 | 7.0 | 4.0-12.0 | 232 | 9.9 | 6.4-15.2 | 221 | 4.7 | 2.6-8.3 | 185 | 6.5 | 3.2-13.0 | 0.056 | 0.812 | |
| 12-23 months | M | 648 | 10.2 | 7.4-14.0 | 528 | 9.1 | 6.8-12.1 | 638 | 8.9 | 6.6-12.0 | 583 | 5.3 | 3.6-7.8 | 5.714 | 0.017 | ↘ |
|  | F | 360 | 8.9 | 5.9-13.3 | 489 | 9.8 | 7.1-13.3 | 385 | 6.4 | 4.3-9.5 | 430 | 4.2 | 2.7-6.6 | 8.977 | 0.003 | ↘ |
| 24-35 months | M | 500 | 6.2 | 4.3-9.0 | 407 | 4.6 | 2.8-7.4 | 472 | 6.1 | 4.0-9.4 | 543 | 9.2 | 5.8-14.3 | 3.139 | 0.077 | |
|  | F | 482 | 6.0 | 4.0-8.8 | 520 | 5.9 | 4.0-8.6 | 426 | 3.5 | 2.0-6.1 | 464 | 4.4 | 2.4-8.0 | 1.431 | 0.232 | |
| **Province** | | | | | | | | | | | | | | | | |
| Nairobi | M | 58 | 4.8 | 1.3-16.3 | 120 | 13.8 | 8.3-22.2 | 111 | 4.6 | 2.1-10.1 | 84 | 9.7 | 4.0-21.7 | 0.010 | 0.922 | |
|  | F | 43 | 0.0 | | 68 | 10.8 | 3.8-26.9 | 88 | 4.9 | 1.2-18.2 | 73 | 2.9 | 0.6-12.5 | 0.089 | 0.766 | |
| Central | M | 199 | 3.5 | 1.4-8.3 | 127 | 9.2 | 5.2-15.9 | 182 | 5.2 | 2.8-9.3 | 122 | 5.2 | 2.5-10.5 | 0.213 | 0.645 | |
|  | F | 159 | 4.6 | 2.0-10.2 | 142 | 8.2 | 3.7-17.1 | 145 | 6.6 | 3.6-11.6 | 110 | 7.2 | 3.6-14.1 | 0.409 | 0.524 | |
| Coast | M | 146 | 13.7 | 9.5-19.4 | 126 | 7.4 | 4.4-12.2 | 167 | 8.2 | 5.0-13.2 | 173 | 13.7 | 8.9-20.5 | 0.012 | 0.913 | |
|  | F | 93 | 13.9 | 8.3-22.3 | 112 | 6.4 | 3.7-10.8 | 97 | 4.7 | 2.1-10.0 | 108 | 11.8 | 7.2-18.7 | 0.172 | 0.679 | |
| Eastern | M | 344 | 10.5 | 7.0-15.6 | 230 | 6.8 | 4.0-11.3 | 321 | 7.9 | 4.7-12.8 | 268 | 4.8 | 2.7-8.2 | 3.981 | 0.048 | ↘ |
|  | F | 248 | 11.7 | 7.3-18.0 | 259 | 6.4 | 3.3-12.1 | 184 | 2.7 | 1.0-7.5 | 233 | 5.7 | 2.8-11.1 | 3.583 | 0.060 | |
| Nyanza | M | 292 | 9.6 | 6.7-13.6 | 312 | 12.9 | 9.0-18.2 | 278 | 6.3 | 3.7-10.6 | 385 | 6.1 | 4.1-9.0 | 6.403 | 0.012 | ↘ |
|  | F | 189 | 5.2 | 2.6-10.0 | 297 | 11.2 | 8.1-15.4 | 201 | 1.5 | 0.5-5.0 | 222 | 4.5 | 2.3-8.7 | 3.496 | 0.063 | |
| Rift-Valley | M | 418 | 10.9 | 7.2-16.3 | 396 | 7.8 | 5.4-11.2 | 520 | 12.6 | 9.0-17.5 | 533 | 13.4 | 10.0-17.8 | 1.794 | 0.182 | |
|  | F | 268 | 7.5 | 4.8-11.6 | 340 | 7.7 | 5.3-11.2 | 323 | 6.3 | 3.9-10.2 | 318 | 6.4 | 3.6-11.2 | 0.375 | 0.541 | |
| Western | M | 333 | 6.8 | 4.4-10.4 | 193 | 6.9 | 4.0-11.8 | 239 | 8.3 | 4.5-14.9 | 242 | 3.8 | 1.6-8.8 | 0.777 | 0.379 | |
|  | F | 181 | 4.2 | 2.0-8.6 | 203 | 7.2 | 4.0-12.6 | 163 | 7.8 | 4.7-12.6 | 158 | 1.5 | 0.5-4.8 | 1.199 | 0.275 | |
| **Residence** | | | | | | | | | | | | | | | | |
| Urban | M | 192 | 6.4 | 3.8-10.7 | 283 | 7.9 | 4.8-12.7 | 324 | 5.6 | 3.6-8.6 | 305 | 7.4 | 4.7-11.5 | 0.001 | 0.973 | |
|  | F | 135 | 5.9 | 3.0-11.5 | 244 | 7.9 | 4.8-12.9 | 222 | 3.8 | 1.7-8.6 | 244 | 3.5 | 1.8-6.6 | 3.611 | 0.058 | |
| Rural | M | 1,598 | 9.4 | 7.7-11.4 | 1,218 | 9.5 | 7.8-11.4 | 1,494 | 9.3 | 7.4-11.5 | 1,502 | 8.8 | 7.0-11.1 | 0.182 | 0.670 | |
|  | F | 1,046 | 7.5 | 5.8-9.6 | 1,177 | 8.3 | 6.6-10.3 | 980 | 5.2 | 3.9-7.0 | 977 | 6.2 | 4.6-8.3 | 2.982 | 0.085 | |
| **Maternal Education** | | | | | | | | | | | | | | | | |
| No education | M | 309 | 16.2 | 11.8-21.9 | 164 | 7.6 | 4.2-13.5 | 236 | 18.4 | 13.0-25.5 | 182 | 18.6 | 13.4-25.3 | 1.126 | 0.289 | |
|  | F | 206 | 12.4 | 8.4-17.8 | 144 | 11.3 | 6.8-18.4 | 155 | 6.0 | 2.7-12.6 | 114 | 8.7 | 4.7-15.4 | 2.498 | 0.115 | |
| Incomplete primary | M | 710 | 9.4 | 7.1-12.2 | 557 | 12.2 | 9.5-15.4 | 678 | 11.1 | 8.5-14.4 | 666 | 8.5 | 6.1-11.6 | 0.296 | 0.587 | |
|  | F | 476 | 6.6 | 4.5-9.7 | 548 | 8.6 | 6.3-11.7 | 456 | 5.7 | 3.8-8.4 | 411 | 4.8 | 2.6-8.4 | 2.006 | 0.157 | |
| Complete primary | M | 366 | 8.0 | 5.6-11.4 | 377 | 9.1 | 6.3-13.1 | 519 | 3.4 | 2.0-5.5 | 562 | 6.6 | 4.5-9.7 | 1.994 | 0.158 | |
|  | F | 226 | 6.4 | 3.6-11.0 | 370 | 8.6 | 5.7-12.8 | 326 | 5.1 | 3.1-8.3 | 363 | 8.9 | 5.6-13.8 | 0.186 | 0.666 | |
| Incomplete secondary | M | 363 | 4.4 | 2.4-7.8 | 148 | 7.3 | 3.7-14.2 | 165 | 5.3 | 2.5-11.0 | 157 | 7.4 | 3.7-14.1 | 1.048 | 0.306 | |
|  | F | 227 | 4.6 | 2.5-8.0 | 132 | 5.1 | 2.2-11.6 | 97 | 4.7 | 1.8-11.6 | 111 | 4.1 | 1.5-10.7 | 0.024 | 0.878 | |

**Table 2 Wasting trends by age, province, residence, maternal education and wealth index, KDHS** (Continued)

| | | N | % | C.I | N | % | C.I | N | % | C.I | N | % | C.I | F | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Secondary + | M | 42 | 1.1 | 0.2-7.9 | 256 | 4.8 | 2.4-9.1 | 220 | 5.3 | 2.8-9.7 | 240 | 6.7 | 3.9-11.5 | 1.718 | 0.190 | |
| | F | 45 | 10.5 | 3.7-26.5 | 225 | 6.6 | 3.8-11.3 | 168 | 1.9 | 0.7-4.7 | 223 | 1.2 | 0.4-3.4 | 14.170 | 0.000 | ↘ |
| **Wealth Index** | | | | | | | | | | | | | | | | |
| Poorest | M | 403 | 15.2 | 11.3-20.2 | 378 | 11.3 | 8.1-15.6 | 442 | 10.7 | 7.2-15.7 | 433 | 13.0 | 9.7-17.2 | 0.601 | 0.439 | |
| | F | 279 | 7.6 | 4.5-12.4 | 345 | 9.3 | 6.5-13.1 | 263 | 6.9 | 4.2-11.2 | 264 | 7.6 | 4.5-12.6 | 0.086 | 0.769 | |
| Poorer | M | 395 | 10.1 | 7.3-13.7 | 302 | 12.2 | 8.8-16.5 | 391 | 10.8 | 7.4-15.4 | 415 | 9.6 | 5.1-17.4 | 0.053 | 0.818 | |
| | F | 240 | 10.9 | 7.4-15.7 | 303 | 8.0 | 5.2-12.2 | 269 | 5.2 | 3.0-9.1 | 243 | 7.0 | 3.4-13.7 | 1.858 | 0.173 | |
| Middle | M | 385 | 6.6 | 4.4-9.6 | 288 | 5.9 | 3.2-10.4 | 347 | 7.5 | 4.8-11.3 | 350 | 5.8 | 3.1-10.6 | 0.010 | 0.922 | |
| | F | 227 | 8.0 | 4.7-13.3 | 258 | 9.8 | 6.3-14.8 | 236 | 3.5 | 1.8-6.6 | 240 | 4.9 | 2.7-8.9 | 3.945 | 0.047 | ↘ |
| Richer | M | 343 | 7.8 | 4.9-12.2 | 271 | 6.0 | 3.6-9.9 | 316 | 7.4 | 4.5-11.7 | 305 | 7.1 | 4.5-10.9 | 0.028 | 0.868 | |
| | F | 231 | 5.1 | 2.6-9.8 | 258 | 8.1 | 4.7-13.5 | 213 | 4.8 | 2.4-9.1 | 246 | 5.7 | 3.1-10.3 | 0.036 | 0.849 | |
| Richest | M | 264 | 3.4 | 1.8-6.4 | 262 | 9.5 | 6.1-14.5 | 323 | 5.6 | 3.5-8.8 | 305 | 5.6 | 3.1-9.8 | 0.100 | 0.752 | |
| | F | 204 | 4.7 | 2.5-8.8 | 256 | 5.6 | 3.2-9.9 | 221 | 4.1 | 1.8-9.1 | 229 | 2.5 | 1.1-5.5 | 1.983 | 0.160 | |

C.I, 95% confidence intervals; Secondary +, complete secondary and/or higher education; ↘ significant decreasing trend.

### Trends in wasting

National trends for boys and girls combined and for boys aged 0–35 months showed no decline in wasting across the study period (Table 2), while wasting did decrease significantly for girls from 7.3% in 1993 to 5.6% in 2008−09 (F(1, 1136) = 5.34, p < 0.021). The decline in girls was concentrated in the age group 12–23 months (F(1, 1046) = 8.98, p < 0.003), and the decline in boys was concentrated in the same age group (F(1, 1046) = 5.71, p < 0.017).

By province, a departure from the overall trends was observed in Eastern and Nyanza provinces. In Eastern province, wasting among boys decreased significantly from 10.5% in 1993 to 4.8% in 2008−9 (F(1, 172) = 3.98, p < 0.048). Boys in Nyanza province posted a significant decline in wasting from 9.6% in 1993 to 6.1% in 2008−9 (F(1, 161) = 6.40, p < 0.012). Analyses by maternal education showed that the prevalence of wasting among girls with mothers having complete secondary and/or higher education declined significantly from 10.5% to 1.2% from 1993 to 2008−9 (F(1, 611) = 14.17, p < 0.000). Trends by urban/rural residence were not statistically significant while those by WI showed girls in the middle quintile decrease from 8.0% in 1993 to 4.9% in 2008−09 (F(1, 735) = 3.95, p < 0.047).

Comparing wasting prevalence between two survey years (1993 versus 2008–09), boys recorded poor growth patterns as compared to girls. Prevalence for boys increased among 6–11 months olds (10.4% to 13.2%), boys in Rift-Valley increased (10.9% to 13.4%), and boys born to mothers with no education (16.2% to 18.6%).

### Trends in stunting

Nationally, prevalence in stunting for boys and girls combined remained stagnant across the survey years.

The gender-specific trends showed boys' trend declining from 41.7% in 1993 to 36.9% in 2008−9 (F(1, 1137) = 4.63, p < 0.032) while the trend for girls was stable (Table 3). There was a worsening trend in stunting for girls aged 12−23 months, with stunting increasing from 31.3% in 1993 to 40.1% in 2008−09 (F(1, 1044) = 4.18, p < 0.041). However among girls aged 24–35 months, stunting declined significantly from 53.1% in 1993 to 43.1% in 2008−09 (F(1, 1017) = 9.88, p < 0.002). Analyses by province showed significant decreases in stunting prevalence for boys in Nyanza from 40.6% in 1993 to 30.8% in 2008−09 (F(1, 162) = 5.35, p < 0.022).

The trends by maternal education were not significant for most sub-groups except a decline in stunting among boys born to mothers with incomplete primary education, from 48.8% in 1993 to 41.5% in 2008−09 (F(1, 956) = 5.05, p < 0.025). By WI, most trends were not statistically significant, with the exception of a decline among boys living in households in the richer WI quintile (F(1, 717) = 5.98, p < 0.015).

While the overall national trend in stunting for boys and girls combined stagnated during the study period, girls' prevalence seemed to have gotten worse in certain socio-demographic segments comparing 1993 versus 2008–09. Stunting prevalence was severe in 1993 and still increased by 2008–09 among girls aged 12–23 months (31.3% to 40.1%), girls born to mothers with no education (42.9% to 44.0%), girls born to mothers with complete primary education (31.8% to 34.7%), and girls belonging to the poorest (44.0% to 46.6%) and middle (34.4% to 39.6%), wealth quintiles.

### Trends in underweight

Table 4 provides the detailed trend analysis for underweight. The national trend for all children and separate

## Table 3 Stunting trends by age, province, residence, maternal education and wealth index, KDHS

| | | 1993 | | | 1998 | | | 2003 | | | 2008-09 | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sex | n | % | C.I. | n | % | C.I. | n | % | C.I. | n | % | C.I. | Wald F | P-value | Trend |
| **Total** | M/F | 2,996 | 39.5 | 37.3-41.7 | 2,951 | 37.1 | 34.9-39.2 | 3,033 | 36.1 | 33.9-38.4 | 3,051 | 36.5 | 33.6-39.5 | 2.681 | 0.102 | |
| | M | 1,805 | 41.7 | 38.9-44.7 | 1,511 | 39.5 | 36.8-42.2 | 1,827 | 38.8 | 36.0-41.6 | 1,822 | 36.9 | 33.7-40.2 | 4.634 | 0.032 | ↘ |
| | F | 1,191 | 36.0 | 32.8-39.3 | 1,440 | 34.5 | 31.7-37.5 | 1,206 | 32.1 | 29.0-35.4 | 1,229 | 35.9 | 31.7-40.3 | 0.089 | 0.766 | |
| **Age** | | | | | | | | | | | | | | | | |
| 0-5 months | M | 276 | 20.5 | 15.4-26.7 | 286 | 17.9 | 13.4-23.6 | 355 | 17.8 | 13.4-23.2 | 320 | 14.3 | 9.0-22.1 | 2.288 | 0.131 | |
| | F | 167 | 10.6 | 6.4-16.9 | 190 | 15.7 | 10.7-22.5 | 169 | 14.5 | 9.5-21.6 | 149 | 15.5 | 8.9-25.8 | 0.135 | 0.713 | |
| 6-11 months | M | 372 | 24.9 | 20.5-29.9 | 290 | 24.5 | 19.1-30.7 | 363 | 21.5 | 16.9-26.9 | 372 | 27.3 | 21.8-33.6 | 0.011 | 0.917 | |
| | F | 178 | 22.9 | 16.4-31.0 | 239 | 18.6 | 13.7-24.7 | 223 | 16.0 | 11.1-22.4 | 184 | 24.3 | 16.6-34.0 | 0.108 | 0.742 | |
| 12-23 months | M | 655 | 52.9 | 48.0-57.8 | 528 | 50.5 | 45.9-55.1 | 642 | 50.4 | 45.5-55.3 | 580 | 49.7 | 43.8-55.5 | 0.488 | 0.485 | |
| | F | 360 | 31.3 | 26.1-37.0 | 489 | 36.9 | 32.5-41.7 | 386 | 38.7 | 33.3-44.3 | 432 | 40.1 | 31.5-49.4 | 4.179 | 0.041 | ↗ |
| 24-35 months | M | 502 | 51.3 | 46.1-56.5 | 407 | 51.0 | 45.5-56.5 | 467 | 52.2 | 46.8-57.6 | 550 | 43.1 | 37.1-49.4 | 3.242 | 0.072 | |
| | F | 485 | 53.1 | 47.6-58.5 | 522 | 46.4 | 41.6-51.3 | 428 | 41.5 | 35.9-47.4 | 464 | 43.1 | 37.6-48.7 | 9.880 | 0.002 | ↘ |
| **Province** | | | | | | | | | | | | | | | | |
| Nairobi | M | 65 | 61.7 | 46.3-75.1 | 120 | 32.3 | 24.0-41.8 | 111 | 29.2 | 22.0-37.6 | 85 | 30.4 | 20.9-41.9 | 8.505 | 0.005 | ↘ |
| | F | 46 | 18.2 | 10.7-29.1 | 66 | 27.8 | 15.4-44.9 | 89 | 18.4 | 11.8-27.6 | 73 | 30.6 | 20.8-42.6 | 0.880 | 0.351 | |
| Central | M | 202 | 45.2 | 36.0-54.7 | 127 | 41.9 | 33.5-50.8 | 188 | 41.2 | 33.7-49.2 | 126 | 37.2 | 29.0-46.1 | 1.317 | 0.253 | |
| | F | 160 | 34.4 | 27.1-42.4 | 145 | 32.4 | 21.8-45.2 | 145 | 31.0 | 23.9-39.0 | 110 | 24.1 | 15.3-35.8 | 2.149 | 0.145 | |
| Coast | M | 145 | 42.0 | 34.4-50.0 | 128 | 48.5 | 36.7-60.5 | 168 | 41.0 | 32.6-50.0 | 174 | 39.9 | 34.3-45.8 | 0.505 | 0.478 | |
| | F | 96 | 47.3 | 37.8-57.0 | 113 | 41.0 | 32.4-50.2 | 98 | 41.3 | 31.4-51.9 | 108 | 42.2 | 28.1-57.7 | 0.224 | 0.636 | |
| Eastern | M | 345 | 46.3 | 39.5-53.2 | 238 | 42.3 | 36.5-48.4 | 319 | 42.6 | 35.0-50.5 | 269 | 43.1 | 37.1-49.4 | 0.457 | 0.500 | |
| | F | 246 | 45.5 | 37.5-53.8 | 261 | 38.9 | 32.5-45.7 | 189 | 33.7 | 24.4-44.5 | 235 | 39.7 | 31.9-48.1 | 1.249 | 0.265 | |
| Nyanza | M | 297 | 40.6 | 34.7-46.8 | 310 | 33.8 | 28.0-40.1 | 279 | 33.2 | 27.3-39.7 | 381 | 30.8 | 26.1-35.9 | 5.347 | 0.022 | ↘ |
| | F | 191 | 37.9 | 31.2-45.1 | 307 | 33.5 | 27.4-40.1 | 204 | 32.2 | 25.1-40.2 | 220 | 35.0 | 28.1-42.6 | 0.262 | 0.609 | |
| Rift-Valley | M | 420 | 39.1 | 32.9-45.6 | 393 | 39.8 | 36.1-43.7 | 516 | 40.3 | 35.0-45.8 | 545 | 41.2 | 33.5-49.4 | 0.178 | 0.673 | |
| | F | 269 | 27.6 | 22.0-34.0 | 346 | 32.9 | 27.4-38.9 | 318 | 32.7 | 27.0-38.9 | 326 | 38.3 | 27.3-50.6 | 2.240 | 0.136 | |
| Western | M | 331 | 35.3 | 29.6-41.5 | 196 | 41.3 | 33.1-50.0 | 245 | 38.0 | 31.2-45.3 | 242 | 30.1 | 25.5-35.2 | 1.235 | 0.268 | |
| | F | 184 | 33.6 | 25.9-42.2 | 201 | 33.4 | 26.9-40.6 | 165 | 32.0 | 24.1-41.1 | 158 | 32.9 | 25.1-41.8 | 0.038 | 0.846 | |
| **Residence** | | | | | | | | | | | | | | | | |
| Urban | M | 199 | 41.9 | 32.7-51.6 | 281 | 30.4 | 24.9-36.5 | 327 | 35.3 | 29.4-41.7 | 307 | 29.5 | 23.7-36.0 | 2.647 | 0.105 | |
| | F | 138 | 17.7 | 12.0-25.5 | 247 | 27.7 | 20.9-35.6 | 223 | 24.4 | 19.5-30.0 | 244 | 25.7 | 16.4-37.7 | 0.452 | 0.502 | |
| Rural | M | 1,606 | 41.7 | 38.7-44.8 | 1,230 | 41.5 | 38.6-44.5 | 1,500 | 39.5 | 36.4-42.7 | 1,515 | 38.4 | 34.9-42.1 | 2.300 | 0.130 | |
| | F | 1,052 | 38.4 | 35.0-41.9 | 1,193 | 36.0 | 32.9-39.2 | 983 | 33.9 | 30.3-37.6 | 985 | 38.4 | 34.1-43.0 | 0.057 | 0.812 | |
| **Maternal Education** | | | | | | | | | | | | | | | | |
| No education | M | 313 | 44.0 | 37.5-50.8 | 166 | 49.3 | 39.4-59.2 | 233 | 41.7 | 32.8-51.2 | 190 | 36.8 | 29.1-45.3 | 1.975 | 0.161 | |
| | F | 209 | 42.9 | 35.3-50.9 | 144 | 43.8 | 34.3-53.8 | 152 | 41.3 | 31.3-52.0 | 114 | 44.0 | 29.9-59.2 | 0.000 | 0.998 | |
| Incomplete primary | M | 716 | 48.8 | 44.6-53.0 | 573 | 44.7 | 40.4-49.1 | 683 | 42.1 | 37.9-46.4 | 664 | 41.5 | 36.2-47.1 | 5.069 | 0.025 | ↘ |
| | F | 475 | 41.1 | 36.0-46.5 | 561 | 39.1 | 34.9-43.5 | 457 | 35.9 | 30.6-41.5 | 410 | 40.6 | 34.6-47.0 | 0.180 | 0.671 | |
| Complete primary | M | 367 | 40.4 | 34.9-46.2 | 380 | 37.8 | 32.7-43.2 | 526 | 38.6 | 33.9-43.5 | 565 | 40.1 | 33.9-46.8 | 0.004 | 0.951 | |
| | F | 228 | 31.8 | 25.5-38.8 | 371 | 38.0 | 32.4-43.8 | 330 | 35.8 | 30.5-41.5 | 369 | 34.7 | 28.7-41.2 | 0.041 | 0.839 | |
| Incomplete secondary | M | 367 | 29.3 | 23.5-35.9 | 139 | 31.9 | 23.8-41.2 | 165 | 39.4 | 30.2-49.4 | 156 | 27.8 | 20.0-37.3 | 0.229 | 0.633 | |
| | F | 232 | 24.3 | 18.7-31.0 | 135 | 27.5 | 20.5-35.8 | 96 | 21.1 | 13.0-32.3 | 112 | 27.4 | 18.3-38.7 | 0.043 | 0.836 | |

**Table 3 Stunting trends by age, province, residence, maternal education and wealth index, KDHS** (Continued)

| | | N | % | C.I | N | % | C.I | N | % | C.I | N | % | C.I | F | p | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Secondary + | M | 42 | 24.0 | 12.6-40.9 | 254 | 28.0 | 22.7-34.0 | 219 | 25.2 | 19.7-31.5 | 247 | 23.1 | 16.7-31.1 | 0.700 | 0.403 | |
| | F | 46 | 31.2 | 18.1-48.2 | 228 | 16.0 | 11.6-21.7 | 171 | 12.8 | 8.8-18.2 | 224 | 29.3 | 20.9-39.5 | 1.749 | 0.187 | |
| **Wealth Index** | | | | | | | | | | | | | | | | |
| Poorest | M | 405 | 48.6 | 42.8-54.5 | 384 | 50.6 | 44.5-56.6 | 448 | 45.8 | 40.9-50.8 | 450 | 42.9 | 36.8-49.3 | 2.568 | 0.110 | |
| | F | 281 | 44.0 | 37.8-50.5 | 353 | 44.0 | 38.1-50.1 | 261 | 40.4 | 33.4-47.9 | 268 | 46.6 | 39.8-53.4 | 0.066 | 0.797 | |
| Poorer | M | 399 | 43.9 | 38.3-49.7 | 303 | 41.7 | 36.0-47.5 | 389 | 38.5 | 33.0-44.3 | 411 | 44.7 | 37.6-51.9 | 0.003 | 0.960 | |
| | F | 243 | 37.7 | 31.6-44.2 | 307 | 40.9 | 34.8-47.3 | 272 | 35.1 | 29.2-41.6 | 247 | 37.4 | 28.8-46.9 | 0.174 | 0.677 | |
| Middle | M | 385 | 40.9 | 34.9-47.2 | 288 | 35.8 | 29.5-42.6 | 350 | 34.5 | 28.5-40.9 | 345 | 32.7 | 26.9-39.1 | 3.596 | 0.058 | |
| | F | 227 | 34.4 | 28.0-41.5 | 261 | 35.6 | 30.1-41.5 | 236 | 34.0 | 27.5-41.1 | 241 | 39.6 | 31.2-48.7 | 0.633 | 0.426 | |
| Richer | M | 346 | 41.7 | 35.9-47.9 | 279 | 38.2 | 32.6-44.1 | 312 | 40.1 | 33.8-46.7 | 304 | 28.9 | 22.5-36.3 | 5.982 | 0.015 | ↘ |
| | F | 232 | 41.8 | 34.8-49.1 | 262 | 31.1 | 24.7-38.4 | 211 | 29.2 | 22.9-36.5 | 241 | 32.5 | 23.4-43.1 | 1.999 | 0.158 | |
| Richest | M | 270 | 29.4 | 23.4-36.2 | 258 | 26.0 | 20.2-32.7 | 328 | 32.9 | 26.5-39.9 | 312 | 30.7 | 23.5-38.9 | 0.439 | 0.508 | |
| | F | 207 | 18.4 | 13.3-25.0 | 259 | 16.5 | 11.7-22.7 | 227 | 19.5 | 15.1-24.8 | 231 | 21.6 | 14.6-30.7 | 0.713 | 0.399 | |

C.I, 95% confidence intervals; Secondary +, complete secondary and/or higher education; ↘ significant decreasing trend; ↗, significant increasing trend.

trends for boys and girls showed significant declines in underweight. Underweight declined among boys and girls combined, from 19.7% in 1993 to 15.0% in 2008–9 ($F_{(1, 1136)} = 11.80$, $p < 0.001$), among boys from 21.4% in 1993 to 16.4% in 2008–09 ($F_{(1, 1136)} = 7.96$, $p < 0.005$), and among girls from 17.2% in 1993 to 12.8% in 2008–09 ($F_{(1, 1136)} = 7.24$, $p < 0.007$). Age specific analysis showed significant declines among boys aged 0–5 months ($F_{(1, 932)} = 9.37$, $p < 0.002$), girls aged 6–11 months ($F_{(1, 925)} = 4.09$, $p < 0.043$), and boys aged 12–23 months ($F_{(1, 1048)} = 8.32$, $p < 0.004$).

Provincial analyses showed significant declines in underweight among boys and girls in Nyanza. Boys' prevalence reduced from 21.6% in 1993 to 14.0% in 2008–09 ($F_{(1, 161)} = 6.95$, $p < 0.009$) and that for girls reduced from 20.9% in 1993 to 10.8% in 2008–09 ($F_{(1, 161)} = 10.39$, $p < 0.002$). Boys and girls residing in rural areas recorded significant declines in underweight with boys' levels reducing from 22.6% in 1993 to 17.1% in 2008–09 ($F_{(1, 871)} = 8.31$, $p < 0.004$), and girls' levels declining from 18.4% in 1993 to 13.8% in 2008–09 ($F_{(1, 871)} = 6.30$, $p < 0.012$).

Most of the trend analyses of maternal education were not statistically significant. Only boys born to mothers with incomplete primary education showed a significant decline from 26.1% in 1993 to 19.4% in 2008–09 ($F_{(1, 967)} = 7.44$, $p < 0.006$). There was a significant declining trend in underweight among boys in the poorest wealth quintile, from 31.7% in 1993 to 24.2% in 2008–09 ($F_{(1, 551)} = 5.40$, $p < 0.020$) and among girls in the richer wealth quintile, from 15.2% in 1993 to 7.6% in 2008–09 ($F_{(1, 716)} = 4.26$, $p < 0.039$). Comparison between the 1993 and 2008–09 surveys showed that prevalence of underweight dropped in 2008–09 in almost all sub-groups.

## Discussion

For each survey year, the wasting prevalence estimate was slightly lower for girls than for boys, which is consistent with previous studies from sub-Saharan Africa [34,35]. The overall national trend for wasting showed no significant change in the study period but there were important differences in the trends by age and sex. Older children aged 12–23 months showed a declining trend. Evidence on child growth patterns from many countries in the developing world shows that the prevalence of wasting is stable at all measurement points from about 12 months of age and on, after a six month period of sharply increasing wasting prevalence following weaning [36]. Therefore, the lessened risk of wasting over time observed in this study among Kenyan 12–23 month olds may be a result of improved post-weaning child care and feeding from the mid-1990's on. This calls for closer investigation of archival data from KDHS and other sources on care and feeding patterns during the past two decades, to observe which care and feeding factors and trends may account for the reduction in wasting. The emphasis on overall care, and not just feeding, is in concert with recent conclusions that proper hygiene practices and access to adequate water, proper sanitation and reliable health services may be as important or even more important determinants of child growth than feeding practices [37].

As to sex differences, wasting among girls overall declined significantly, while remaining stable among boys. Yet some groups of boys did improve. Using a liberal criterion for significance of $p < 0.10$, the pattern of significant trends in wasting (12 trends as shown in Table 2) were all in the direction of improvement, observed predominantly in females. But trends in wasting also showed significant improvement among older boys and

### Table 4 Underweight trends by age, province, residence, maternal education and wealth index, KDHS

| | | 1993 | | | 1998 | | | 2003 | | | 2008-09 | | | Wald F | P-value | Trend |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sex | n | % | C.I. | n | % | C.I. | n | % | C.I. | n | % | C.I. | | | |
| **Total** | M/F | 3,115 | 19.7 | 17.9-21.6 | 3,051 | 17.6 | 16.0-19.4 | 3,148 | 16.0 | 14.4-17.8 | 3,147 | 15.0 | 13.0-17.2 | 11.804 | 0.001 | ↘ |
| | M | 1,881 | 21.4 | 19.1-23.8 | 1,580 | 19.4 | 17.2-21.9 | 1,880 | 18.7 | 16.4-21.2 | 1,890 | 16.4 | 14.1-19.1 | 7.964 | 0.005 | ↘ |
| | F | 1,234 | 17.2 | 14.6-20.2 | 1,471 | 15.6 | 13.6-18.0 | 1,269 | 12.1 | 10.0-14.5 | 1,257 | 12.8 | 10.3-15.7 | 7.237 | 0.007 | ↘ |
| **Age** | | | | | | | | | | | | | | | | |
| 0-5 months | M | 307 | 13.4 | 9.6-18.4 | 309 | 9.3 | 6.1-14.0 | 381 | 9.8 | 6.7-13.8 | 352 | 5.1 | 3.0-8.4 | 9.369 | 0.002 | ↘ |
| | F | 178 | 7.6 | 4.5-12.5 | 195 | 8.9 | 5.4-14.4 | 2,001 | 4.4 | 2.2-8.6 | 160 | 5.8 | 2.6-12.5 | 1.781 | 0.182 | |
| 6-11 months | M | 379 | 18.0 | 14.0-22.8 | 305 | 16.4 | 12.3-21.4 | 370 | 17.0 | 13.3-21.6 | 386 | 18.2 | 12.3-26.0 | 0.016 | 0.898 | |
| | F | 189 | 14.1 | 9.4-20.6 | 242 | 10.6 | 6.9-16.2 | 229 | 8.4 | 5.3-13.2 | 187 | 6.2 | 3.2-11.9 | 4.093 | 0.043 | ↘ |
| 12-23 months | M | 674 | 26.4 | 22.4-30.9 | 546 | 22.1 | 18.4-26.1 | 649 | 22.1 | 18.0-26.9 | 597 | 17.9 | 14.5-22.0 | 8.317 | 0.004 | ↘ |
| | F | 371 | 17.6 | 13.5-22.5 | 504 | 16.8 | 13.4-20.8 | 396 | 15.0 | 11.4-19.5 | 439 | 11.4 | 7.5-16.8 | 1.720 | 0.190 | |
| 24-35 months | M | 520 | 22.1 | 18.4-26.2 | 420 | 25.8 | 21.2-30.9 | 480 | 22.2 | 18.0-27.2 | 555 | 20.9 | 16.1-26.7 | 0.146 | 0.702 | |
| | F | 496 | 21.6 | 17.3-26.6 | 530 | 19.3 | 16.0-23.2 | 443 | 14.9 | 11.3-19.5 | 470 | 19.0 | 15.1-23.8 | 3.309 | 0.069 | |
| **Province** | | | | | | | | | | | | | | | | |
| Nairobi | M | 72 | 11.5 | 4.9-24.9 | 121 | 13.6 | 8.2-21.8 | 114 | 6.2 | 3.1-12.2 | 93 | 9.2 | 5.2-15.7 | 1.198 | 0.277 | |
| | F | 51 | 2.7 | 0.4-15.4 | 72 | 2.6 | 0.4-14.7 | 91 | 4.5 | 2.1-9.5 | 80 | 7.3 | 2.7-18.4 | 1.330 | 0.252 | |
| Central | M | 201 | 16.0 | 12.1-21.0 | 138 | 8.4 | 4.6-14.7 | 188 | 12.3 | 8.4-17.8 | 131 | 12.7 | 5.7-25.7 | 0.313 | 0.576 | |
| | F | 165 | 10.8 | 6.5-17.2 | 149 | 10.8 | 5.8-19.1 | 154 | 9.0 | 5.3-15.0 | 115 | 10.3 | 5.6-18.1 | 0.077 | 0.782 | |
| Coast | M | 173 | 29.5 | 23.0-36.9 | 134 | 23.4 | 15.1-34.5 | 178 | 19.9 | 14.7-26.3 | 178 | 23.2 | 17.3-30.4 | 1.807 | 0.181 | |
| | F | 110 | 25.7 | 17.5-36.2 | 115 | 19.4 | 14.4-25.4 | 102 | 13.8 | 8.2-22.3 | 109 | 20.9 | 14.4-29.5 | 1.015 | 0.315 | |
| Eastern | M | 357 | 23.7 | 18.2-30.4 | 256 | 22.2 | 16.9-28.7 | 326 | 20.7 | 15.8-26.8 | 275 | 16.9 | 12.0-23.2 | 2.548 | 0.112 | |
| | F | 262 | 24.3 | 16.9-33.7 | 270 | 18.4 | 14.0-23.8 | 195 | 11.4 | 6.6-19.1 | 235 | 14.3 | 8.6-23.1 | 3.711 | 0.056 | |
| Nyanza | M | 308 | 21.6 | 17.4-26.6 | 315 | 22.7 | 17.6-28.8 | 291 | 14.6 | 10.1-20.8 | 398 | 14.0 | 9.9-19.4 | 6.951 | 0.009 | ↘ |
| | F | 193 | 20.9 | 15.1-28.1 | 302 | 20.2 | 14.8-27.0 | 214 | 9.1 | 5.2-15.5 | 226 | 10.8 | 7.0-16.3 | 10.394 | 0.002 | ↘ |
| Rift-Valley | M | 432 | 24.0 | 18.9-30.1 | 417 | 19.0 | 15.3-23.5 | 537 | 23.0 | 18.0-28.9 | 570 | 20.2 | 15.7-25.5 | 0.403 | 0.526 | |
| | F | 271 | 12.8 | 9.2-17.6 | 357 | 13.8 | 10.1-18.4 | 347 | 15.1 | 10.7-21.0 | 331 | 13.6 | 8.2-21.6 | 0.075 | 0.784 | |
| Western | M | 337 | 16.4 | 12.1-22.0 | 197 | 20.0 | 13.2-29.1 | 245 | 21.0 | 14.8-28.9 | 245 | 11.1 | 6.4-18.5 | 0.768 | 0.382 | |
| | F | 181 | 14.4 | 9.8-20.6 | 207 | 14.6 | 9.7-21.5 | 165 | 16.4 | 11.3-23.2 | 161 | 10.4 | 6.7-15.8 | 0.751 | 0.388 | |
| **Residence** | | | | | | | | | | | | | | | | |
| Urban | M | 215 | 12.2 | 8.2-17.8 | 294 | 12.0 | 8.0-17.6 | 335 | 13.7 | 9.2-19.9 | 319 | 13.0 | 8.9-18.7 | 0.144 | 0.704 | |
| | F | 145 | 8.3 | 4.1-15.9 | 256 | 9.5 | 6.5-13.5 | 241 | 7.4 | 4.4-12.1 | 254 | 8.5 | 4.6-15.3 | 0.025 | 0.874 | |
| Rural | M | 1,665 | 22.6 | 20.1-25.2 | 1,286 | 21.2 | 18.7-23.9 | 1,544 | 19.7 | 17.2-22.6 | 1,570 | 17.1 | 14.5-20.1 | 8.309 | 0.004 | ↘ |
| | F | 1,089 | 18.4 | 15.5-21.6 | 1,215 | 16.9 | 14.5-19.6 | 1,028 | 13.2 | 10.8-16.0 | 1,003 | 13.8 | 11.1-17.1 | 6.301 | 0.012 | ↘ |
| **Maternal Education** | | | | | | | | | | | | | | | | |
| No education | M | 331 | 30.7 | 25.0-37.2 | 174 | 31.1 | 22.3-41.6 | 244 | 32.1 | 25.1-40.0 | 197 | 27.4 | 21.1-34.8 | 0.233 | 0.629 | |
| | F | 220 | 27.0 | 20.3-35.0 | 148 | 27.0 | 19.5-36.0 | 168 | 19.2 | 13.5-26.7 | 115 | 22.2 | 13.9-33.4 | 1.540 | 0.215 | |
| Incomplete primary | M | 743 | 26.1 | 22.7-29.8 | 596 | 25.8 | 21.9-30.2 | 704 | 21.5 | 18.0-25.4 | 681 | 19.4 | 15.5-23.9 | 7.439 | 0.006 | ↘ |
| | F | 494 | 18.6 | 15.1-22.8 | 569 | 17.9 | 14.2-22.4 | 476 | 13.4 | 10.1-17.5 | 419 | 15.3 | 11.5-20.2 | 2.466 | 0.117 | |
| Complete primary | M | 383 | 16.8 | 13.1-21.3 | 395 | 13.8 | 10.7-17.7 | 538 | 15.1 | 11.8-19.2 | 590 | 15.5 | 11.4-20.6 | 0.034 | 0.854 | |
| | F | 231 | 11.8 | 7.9-17.4 | 384 | 16.1 | 12.6-20.4 | 348 | 12.8 | 8.8-18.3 | 376 | 14.2 | 9.8-20.1 | 0.023 | 0.880 | |
| Incomplete secondary | M | 383 | 10.3 | 7.3-14.3 | 152 | 11.0 | 6.5-17.9 | 167 | 13.0 | 7.6-21.4 | 164 | 11.0 | 6.4-18.3 | 0.239 | 0.625 | |
| | F | 243 | 11.4 | 7.5-16.9 | 139 | 9.4 | 5.3-15.9 | 102 | 4.1 | 1.3-12.4 | 115 | 7.1 | 3.7-13.3 | 2.837 | 0.093 | |

**Table 4 Underweight trends by age, province, residence, maternal education and wealth index, KDHS** (Continued)

| | | N | % | C.I | N | % | C.I | N | % | C.I | N | % | C.I | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Secondary + | M | 42 | 8.6 | 2.4-26.4 | 263 | 10.5 | 6.4-16.7 | 227 | 8.1 | 4.9-13.1 | 258 | 6.0 | 3.6-9.8 | 2.163 | 0.142 | |
| | F | 46 | 12.8 | 5.2-28.2 | 232 | 5.6 | 3.3-9.5 | 175 | 5.0 | 2.5-9.6 | 232 | 3.9 | 1.8-8.1 | 2.529 | 0.112 | |
| **Wealth Index** | | | | | | | | | | | | | | | | |
| Poorest | M | 419 | 31.7 | 26.3-37.5 | 398 | 30.9 | 25.6-36.7 | 457 | 24.1 | 19.3-29.6 | 463 | 24.2 | 19.3-29.8 | 5.402 | 0.020 | ↘ |
| | F | 290 | 22.6 | 17.4-28.7 | 353 | 22.0 | 17.6-27.1 | 277 | 18.4 | 13.2-25.1 | 271 | 16.9 | 12.4-22.6 | 2.718 | 0.100 | |
| Poorer | M | 415 | 25.4 | 20.9-30.6 | 317 | 21.6 | 17.5-26.3 | 398 | 20.7 | 15.8-26.6 | 424 | 19.7 | 14.6-26.0 | 2.204 | 0.138 | |
| | F | 248 | 20.3 | 15.2-26.5 | 317 | 17.6 | 12.8-23.7 | 282 | 12.4 | 8.5-17.9 | 251 | 15.9 | 10.5-23.3 | 1.788 | 0.182 | |
| Middle | M | 396 | 17.5 | 13.9-21.7 | 308 | 14.3 | 10.3-19.5 | 359 | 16.9 | 12.8-22.0 | 358 | 10.9 | 7.3-15.9 | 3.208 | 0.074 | |
| | F | 237 | 17.6 | 12.7-23.9 | 271 | 16.0 | 11.8-21.5 | 243 | 14.5 | 10.4-19.8 | 246 | 17.9 | 11.9-26.0 | 0.001 | 0.980 | |
| Richer | M | 367 | 19.3 | 15.2-24.2 | 289 | 17.4 | 12.8-23.2 | 329 | 18.1 | 13.9-23.2 | 318 | 13.4 | 8.2-21.0 | 1.808 | 0.179 | |
| | F | 241 | 15.2 | 10.5-21.5 | 263 | 11.9 | 7.9-17.6 | 223 | 7.8 | 4.3-13.6 | 248 | 7.6 | 3.8-14.7 | 4.264 | 0.039 | ↘ |
| Richest | M | 285 | 8.6 | 5.6-12.9 | 268 | 8.1 | 5.2-12.3 | 337 | 11.3 | 7.2-17.3 | 326 | 10.4 | 6.0-17.4 | 0.691 | 0.406 | |
| | F | 219 | 8.4 | 5.0-13.8 | 269 | 8.2 | 5.4-12.3 | 244 | 6.1 | 3.4-10.8 | 241 | 4.9 | 2.6-9.2 | 2.238 | 0.135 | |

C.I, 95% confidence intervals; Secondary +, complete secondary and higher education; ↘, significant decreasing trend.

those living in Eastern and Nyanza provinces. The favourable trends in these provinces for both girls and boys are noteworthy, since Eastern province experiences marked perennial food shortages, while Nyanza is among the provinces with the highest poverty levels in Kenya [38,39]. Climate research in the Eastern province has observed no discernible increasing or decreasing trend either in the annual or seasonal rainfall from 1960's to the present [40]. It seems unlikely that changing weather conditions might have resulted in improved local food production. In light of this, one possible explanation for the improved wasting trends is the impact of food security initiatives, such as the Kenya Special Programme [39]. However, returning to the theme that overall care may be as important as feeding care, evidence from many countries suggests the importance to child growth of policies in diverse arenas. These include immunization, safe water provision, female literacy, income distribution and support for agriculture [41]. Since it is unlikely that there is any single source within countries with expertise and information on all these features of social and political life, transdisciplinary research [42] seems essential to develop better appreciation of the factors that underpin the trends in child growth reported here.

Similar to wasting, trends in stunting at a national level remained stagnant. However, stratification by sex showed a decline among boys. The high prevalence in stunting among boys as compared to girls is in agreement with the literature on stunting in sub-Saharan Africa [11], but the improvement over time in boys, more so than in girls, is difficult to explain. Looking to family dynamics, the literature on parental sex bias in relation to child care and feeding practices is contradictory and the evidence for bias is scarce [12,13,35]. DHS data have been brought to bear on this subject, but only via indirect inferences based

on parental education differences [35]. Due to data limitations, the DHS, and most other survey data for that matter, may be inadequate for direct investigations of social and psychological factors underlying sex differences in child growth. Supporting this view is Marcoux's meta study of 306 child nutrition surveys from across the developing world, of which 74 percent showed no sex differences in wasting, stunting and underweight [43]. That sex differences are difficult to detect reliably in survey research recommends against the use of the survey study design in the search for factors underlying sex differences in child growth. Mixed methods studies of cohorts, and of cases and controls, may be more illuminating.

Analyses by age showed stunting to be relatively lower in younger children and increased with age, in line with other research evidence that the prevalence of stunting increases with age [44]. The comparatively low and stable prevalence posted by children in the youngest age category (0–5 months) is likely due to stable childcare and feeding practices during the pre-weaning stage of development. Actually, in Kenya exclusive breastfeeding increased from 12.7% in 2003 to 31.9% in 2009, while early complimentary feeding at the age of 2–3 months decreased from 81% in 1993 to 32% by 2008 [7]. That stunting in this age group did not show a decline is likely due to a 'floor effect', with near lowest feasible levels of stunting already achieved by the mid-1990's.

The high levels of stunting among children above 12 months and the increasing trend in stunting among girls aged 12–23 months indicates the seriousness of stunting, which seems to manifest itself at the onset of complimentary feeding. Studies have shown that foods used to compliment breastfeeding in Kenya are of low nutritive value [45]. The most preferred porridge is made of composite flours causing negative nutrient-nutrient

**Table 5 Growth and socio-demographic characteristics of the samples, KDHS**

| | 1993 | | 1998 | | 2003 | | 2008-09 | |
|---|---|---|---|---|---|---|---|---|
| | n | % | n | % | n | % | n | % |
| **Growth** | | | | | | | | |
| Wasted | 249 | 8.4 | 255 | 8.7 | 216 | 7.2 | 224 | 7.4 |
| Stunted | 1,182 | 39.5 | 1,094 | 37.1 | 1,095 | 36.1 | 1,114 | 36.5 |
| Underweight | 615 | 19.7 | 537 | 17.6 | 504 | 16.0 | 471 | 15.0 |
| **Sex** | | | | | | | | |
| Male | 2,020 | 60.1 | 1,647 | 51.4 | 1,930 | 59.4 | 1,917 | 60.0 |
| Female | 1,343 | 39.9 | 1,559 | 48.6 | 1,320 | 40.6 | 1,281 | 40.0 |
| **Age** | | | | | | | | |
| 0-5 months | 521 | 15.5 | 523 | 16.3 | 603 | 18.6 | 516 | 16.1 |
| 6-11 months | 593 | 17.6 | 564 | 17.6 | 615 | 18.9 | 585 | 18.3 |
| 12-23 months | 1,124 | 33.4 | 1,097 | 34.2 | 1,080 | 33.2 | 1,048 | 32.8 |
| 24-35 months | 1,126 | 33.5 | 1,021 | 31.9 | 952 | 29.3 | 1,049 | 32.8 |
| **Province** | | | | | | | | |
| Nairobi | 157 | 4.7 | 213 | 6.7 | 216 | 6.7 | 181 | 5.6 |
| Central | 390 | 11.6 | 296 | 9.2 | 357 | 11.0 | 249 | 7.8 |
| Coast | 310 | 9.2 | 263 | 8.2 | 290 | 8.9 | 289 | 9.0 |
| Eastern | 668 | 19.9 | 546 | 17.0 | 537 | 16.5 | 514 | 16.1 |
| Nyanza | 526 | 15.6 | 641 | 20.0 | 510 | 15.7 | 630 | 19.7 |
| Rift-Valley | 769 | 22.9 | 824 | 25.7 | 924 | 28.4 | 927 | 29.0 |
| Western | 543 | 16.2 | 423 | 13.2 | 417 | 12.8 | 408 | 12.8 |
| **Residence** | | | | | | | | |
| Urban | 430 | 12.8 | 600 | 18.7 | 607 | 18.7 | 591 | 18.5 |
| Rural | 2,934 | 87.2 | 2,606 | 81.3 | 2,644 | 81.3 | 2,608 | 81.5 |
| **Maternal Education** | | | | | | | | |
| No education | 614 | 18.3 | 339 | 10.6 | 432 | 13.3 | 318 | 9.9 |
| Incomplete primary | 1,320 | 39.2 | 1,221 | 38.1 | 1,209 | 37.2 | 1,115 | 34.9 |
| Complete primary | 665 | 19.8 | 811 | 25.3 | 914 | 28.1 | 982 | 30.7 |
| Incomplete secondary | 670 | 19.9 | 306 | 9.6 | 281 | 8.6 | 283 | 8.8 |
| Secondary + | 94 | 2.8 | 528 | 16.5 | 416 | 12.8 | 501 | 15.7 |
| **Wealth Index** | | | | | | | | |
| Poorest | 762 | 22.7 | 782 | 24.4 | 752 | 23.1 | 745 | 23.3 |
| Poorer | 702 | 20.9 | 663 | 20.7 | 695 | 21.4 | 684 | 21.4 |
| Middle | 672 | 20.0 | 606 | 18.9 | 620 | 19.1 | 610 | 19.1 |
| Richer | 657 | 19.5 | 581 | 18.1 | 571 | 17.6 | 576 | 18.0 |
| Richest | 570 | 16.9 | 573 | 17.9 | 614 | 18.9 | 584 | 18.3 |

Secondary +, complete secondary and/or higher education.

interactions and also causing mal-absorption due to the child's immature gut. Such foods are also high in anti-nutrients such as phytates and tannins that bind available nutrients and thus reduce bioavailability [45]. Further research is needed to explore the possibility that the nutritive value of the food served to girls in this age segment has worsened over the study period. The significant improvement among older children, especially among girls aged 24–35 months, could be an indication of older girls responding better to nutritional interventions leading to catch up growth [36], but more research is needed to investigate this issue.

The significant improvements in stunting levels in Nairobi could be attributed to the accrued social-economic

and infrastructural advantage enjoyed in the capital region in terms of the number of health facilities and personnel, higher literacy levels and better economic performance [46]. As in the case of wasting, the improvement in stunting among boys in Nyanza province was unexpected due to its high incidence of poverty. Nevertheless, Nyanza province has witnessed an increase in literacy levels [38] and this could be one of the contributing factors to better growth, as maternal literacy is associated with reduced risk of stunting [47,48].

Higher socio-economic status is associated with better utilization of health care services, better access to food of high quality and quantity, better nutrition, improved sanitation and household possessions [49,50]. This advantage was observed in the present study, with a significant reduction in stunting observed among children in rich households but not in poor ones. The public health significance of this pattern is alarming, even though Kenya experienced a decrease in the percentage of people living in poverty. It is estimated that the number of people living below the poverty line increased from 13.4 million in 1997 to about 16.6 million in 2006 [51], increasing the number of children in poor households and at risk of stunting.

Overall, the results show that faltering child growth remains a significant public health challenge in Kenya. It is beyond the present scope to undertake an analysis of causes of faltering growth in the Kenyan context. Here, we must be content merely to point to the complexity of the causal landscape, and the need for research that goes beyond the simple descriptive analyses presented in this paper. Among the critical causes of faltering child growth are poor agricultural performance and food distribution at a macro level, and micronutrient deficiency at the level of individuals. At the macro level, there was a worrying decline in productivity in the Kenyan agricultural sector from a real growth rate of 4.4% in 1996 to −5.4% in 2008. This poor performance translates to less food for the fast-growing Kenyan population, poor economic returns as a result of a decline in agricultural export earnings, and increased unemployment due to the decrease in household farm incomes [46,50,52].

At the individual level, dietary zinc in particular is essential in bolstering immunity, protein metabolism and linear growth, and its deficiency precipitates retarded growth [49]. Bwibo and Nuemann observed that food served to Kenyan children has multiple micronutrient deficiencies, placing child at risk of poor growth regardless of the quantity of food provided by the agricultural sector [45].

This span from macro to micro level causal factors illustrates the complexity of the causal web that underlies faltering child growth, to which an array of sub-optimal childcare practices and inadequate access to health care also contribute. This complexity is signaled strongly in the present findings that compare child growth trends in urban and in rural areas. While the terms 'urban' and 'rural' are demographic concepts referring to population number and density, urban versus rural living conditions include important variation in social factors, such as rates of unemployment and illiteracy, access to health facilities, and household and community poverty level [53]. The declining trends in underweight in rural areas as compared to stagnant trends in urban areas underscore the possibility that urban areas are experiencing a decline in their perceived advantage over rural areas [54]. The high urbanization rate brought about by rural–urban migration has significantly reduced the infrastructural advantage urban areas used to enjoy, and has resulted in increased urban poverty. While hardcore poverty declined in rural areas from 34.8% in 1997 to 21.9% in 2005/06, it increased marginally in urban areas from 7.6% in 1997 to 8.3% in 2005/06 [46]. Further research on urban/rural child growth patterns should therefore be complemented by studies of changing urban and rural living conditions, so that the context of child growth is better appreciated. This should include differentiation between urban areas generally and those in capital regions such as Nairobi, which may enjoy special advantages due to proximity to central government.

### Study limitations

The more data points over time the more robust the trend analysis. With just the four data points (1993, 1998, 2003 and 2008–09) available for the present analyses, we treat our findings and interpretations with due caution. However, we are not aware of any other data on child undernutrition in Kenya with more than four data points over time, and therefore consider the present effort defensible in the interest of providing the best trend estimates possible with the limited data now available.

While decomposed analysis enables detailed understanding of trends within socio-demographic groups, it results in reduction in sample size. Trends in certain groups may fail to reach statistical significance, not necessarily due to lack of changes in prevalence, but rather to limited sample size giving rise to wider confidence intervals around prevalence estimates. It is not only relatively small sample size, but also sample size variation, that may hinder comparison of trends across socio-demographic groups. For example, two sub-group trend analyses with identical prevalence estimates at four points in time may be judged statistically significant in the sub-group with a relatively large n and insignificant in the sub-group with a relatively smaller n. In surveys wherein the sampling design has not included sampling strata at the level of socio-demographic sub-groups, such as the DHS, the limitations associated with variable n that were encountered in this study cannot be overcome.

An alternative to the decomposition approach (stratification) we have taken is to use multivariate analysis to control statistically for population composition changes over time, and to control for confounding and for effect modification (interactions amongst risk and protective factors). While statistically elegant, the main value of such multivariate analyses is to produce equations that predict future changes in outcome variables as a function of hypothesized changes in risk and protective factors. This approach has less utility for policy work than the decomposition approach, which produces more easily digestible information about sub-group trends. Nevertheless, it is a limitation of the present study that the multivariate relationships among the factors defining socio-demographic sub-groups have not been taken into account in the analyses of undernutrition prevalence.

## Conclusions

The national trends in childhood undernutrition in Kenya showed significant declines in underweight, but trends in wasting and stunting were stagnant. Analyses disaggregated by demographic and socio-economic segments revealed some departures from the overall trends. There were more declines in wasting among girls than boys in the various socio-demographic stratifications studied, and the opposite was true for stunting, with boys posting more declining trends compared to girls. These findings support the importance of conducting trend analyses at disaggregated levels within countries, if findings are to be useful in informing public health policy and the development of better-targeted childcare interventions. Concerted efforts should be made by relevant stakeholders to reduce the stagnating trends of undernutrition, especially for stunting, which has consistently remained high in most socio-demographic segments in Kenya.

## Endnotes

[a]Since the promulgation of the new constitution in 2010, provinces were renamed as regions.

[b]The KDHS is one of the MEASURE DHS projects in developing countries that collect data on important health indicators. It is a collaboration involving the Kenya National Bureau of Statistics, National AIDS Control Council, Ministry of Public Health and Sanitation, Kenya Medical Research Institute, National Coordinating Agency for Population and Development, ICF Macro, The United States Agency for International Development (USAID) and other non-governmental organizations.

## Abbreviations

WI: Wealth index; KDHS: Kenya demographic and health survey; SPSS: Statistical package for the social sciences; SD: Standard deviations; WHZ: Weight-for-height Z-score; WLZ: Weight-for-length Z-score; HAZ: Height-for-age Z-score; LAZ: Length-for-age Z-score; WAZ: Weight-for-age Z-score; DHS: Demographic and health survey.

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