

The Double Burden of Undernutrition and Overnutrition in Developing Countries: an Update

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Abstract Many developing countries have achieved a remarkable improvement in nutrition status in the past decades. However, the prevalence of undernutrition remains a serious problem. At the same time, the prevalence of obesity is increasing substantially, and in some countries, it has approached that of developed countries. This article provides an update on this double burden of malnutrition (DBMN) in developing nations. One hundred countries (lower, middle-lower, and upper-middle income countries) were selected and analysed, and to support the analysis, a systematic review of current published studies was performed. The results show that DBMN already exists in almost all developing countries and that the DBMN ratio (i.e., overweight/underweight) has increased as income per capita has increased. DBMN may manifest within the community, household, or individual. In addition to common factors, poor nutrition in early childhood is suggested as another important driving factor behind the rising obesity rate in most developing countries. A life-course approach has been proposed to prevent undernutrition and overnutrition and should be integrated into the development of health systems to control double burden in developing countries.

Keywords Underweight · Overweight · Obesity · Double burden · Malnutrition · Developing countries

Introduction

The double burden of malnutrition (DBMN; undernutrition and overnutrition) is an emerging crisis in most developing countries today [1•, 2, 3••]. Although remarkable improvement in nutrition status has been achieved in the past decades, undernutrition (i.e., underweight, wasting, and growth stunting) remains a serious public health problem in many developing countries [4]. It has been reported that 98.4 million children in Asia have stunted growth, whereas in sub-Saharan Africa, the prevalence is essentially unchanged, from 45.7 million children in 1990 to 55.8 million in 2010 [5].

At the same time, the prevalence of obesity is increasing substantially and, in many countries, approaches that of developed countries [6]. The latest study [7] reports that the prevalence of overweight in developing countries increased by 11 % from 1980 to 2013, approximately 2 % higher than the rate in developed countries. This rate is increasing as the prevalence of childhood overweight and obesity in developing countries is rising. In nations such as Kiribati, the Federated States of Micronesia, Libya, Tonga, and Samoa, more than 50 % of women now have obesity [7]. One study [8] estimates that 62 % of the world's obese people live in developing countries.

This DBMN situation poses a significant challenge [1•] for most developing countries and will pose a new threat to the health system, future economic growth [8], and human well-being [9]. This article provides an update on the situation of double burden in developing countries (in lower, lower-middle, and upper-middle income countries) by analysing the latest prevalence of underweight and overweight collected by the

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World Health Organization (WHO). To support this analysis, the authors conducted a systematic review of published studies examining DBMN in developing countries. The first part of the article presents the current prevalence of undernutrition and overnutrition results from analysing the current prevalence of malnutrition and presents some key features of DBMN results from published studies.

Methods

Source of Data

WHO Global InfoBase data were used to examine the current situation of double burden in developing countries. These data are in the public domain and may be accessed at <https://apps.who.int/infobase>. For the purpose of this analysis, data were accessed on March 5, 2015, and only countries with complete data on both undernutrition and overnutrition were included in the analysis.

One hundred developing countries were identified as eligible for the purpose of this analysis. To examine the different levels of double burden across economic income groups, the countries were classified into three different income levels—lower, lower-middle, and upper-middle—in six different WHO regions (Africa, Americas, eastern Mediterranean, Europe, southeast Asia, and western Pacific). The analysis of underweight was focused on the prevalence of underweight of children under five (low weight-for-age according to the WHO child growth standards), as this is an important indicator for monitoring population nutritional status and health where overweight was defined as BMI of age 20+ ≥ 25 kg/m². Overweight was focussed on age 20+ which defined as BMI ≥ 25 kg/m². The ratio of overweight to underweight was used to measure the figure of double burden of malnutrition.

Search Method for Published Studies

To support the analysis of the current situation of DBMN, a systematic review of published studies was conducted. A search was undertaken in PubMed using a combination of undernutrition- or overnutrition-related keywords; the subject headings are detailed in box 1. First, a keyword search was performed on either the abstracts or titles of articles, resulting in the identification of a great number ($n=212,483$) of articles. The search then was limited to titles ($n=79,485$). Of these articles, 704 focused on developing countries. The titles of these 704 articles were scanned, resulting in the exclusion of 646 articles, leaving 58 articles for detail assessment. Although some articles seemed relevant at the title stage, after the abstracts were read, it was clear that the studies did not examine or review double burden but mostly analysed either

undernutrition or overnutrition. Only the studies discussing DBMN were included in the analysis for this study ($n=28$).

Box 1. Search terms used for the review

(Nutrition surveys [Title/Abstract] OR Nutrition policy [Title/Abstract] OR Nutritional assessment [Title/Abstract] OR Excess bodyweight [Title/Abstract] OR excess body weight [Title/Abstract] OR Over nutrition [Title/Abstract] OR overnutrition [Title/Abstract] OR Overweight [Title/Abstract] OR over weight [Title/Abstract] OR Obesity [Title/Abstract] OR Rickettsia [Title/Abstract] OR Malnutrition [Title/Abstract] OR Undernutrition [Title/Abstract] OR undernutrition [Title/Abstract] OR Kwashiorkor [Title/Abstract] OR Stunting [Title/Abstract] OR Stunted [Title/Abstract] OR Underweight [Title/Abstract] OR Under weight [Title/Abstract] OR (double burden [Title/Abstract] OR dual burden [Title/Abstract] OR nutritional transition [Title/Abstract] AND developing country [MeSH Terms])

Results and Discussion

Undernutrition Prevalence

Undernutrition commonly is defined as wasting, stunting, or micronutrient deficiencies (i.e., anaemia, zinc, and vitamin A) [3••]. Wasting and stunting each indicate a different nutritional deficiency problem [5]. Wasting (low weight for height) is acute malnutrition associated with insufficient food intake to meet protein and energy needs. Wasting often is observed in developing countries with chronic or acute periods of food insecurity and is exacerbated by infectious disease [10].

Stunting (low height for age) or linear growth faltering is a reflection of chronic malnutrition that might occur even in regions and households with apparent food security [11]. Stunting may be an independent condition or may occur along with wasting [5]. Stunting even may exist in the presence of overweight and obesity. The concept of stunted obesity reflects a true DBMN [12, 13]. However, the latest data regarding the prevalence of stunting are not always widely available for most developing countries.

Currently, the prevalence of underweight in developing countries is approximately 13.2 % (range, 1–43.9 %), although it varies depending on a country's economic development category. In lower income countries, the average prevalence is 21.6 % (range, 8.7–38.8 %), much higher than that of lower-middle and upper-middle income countries: 11.1 and 4.34 %, respectively. In Africa and Asia (southeast Asia and western Pacific WHO member countries), the prevalence of underweight is 15.5 % (range, 1–43.9 %) and 19.7 % (range, 3.3–43.9 %), respectively (Table 1 and Fig. 1). In Africa particularly, a study reported that there was no change in the prevalence of stunting or wasting in the past three decades; in 2013, an estimated 55.8 million African children were stunted [5].

Table 1 Prevalence of overweight and underweight and the ratio of overweight to underweight in 100 developing countries

Region, income, and country ^a	GNI	% Underweight (age < 5 years)			% Overweight (BMI ≥ 25) – Age 20+ (95 % CI) ^c			Underweight/overweight ^d	
		Year ^b	Female	Male	Total	Female	Male		Total
Southeast Asia									
Low income									
Myanmar	n.a.	2010	22.1	23.0	22.6	23.6 [16.0–31.5]	13.8 [9.6–18.7]	18.8 [14.3–23.4]	1.1
Republic of Korea	n.a.	2012	15.0	15.5	15.2	15.3 [1.8–40.7]	19.6 [4.3–43.0]	17.4 [5.4–33.8]	1.0
Nepal	730	2011	28.4	29.8	29.1	8.9 [5.3–14.1]	9.8 [2.8–22.0]	9.3 [5.2–15.4]	0.3
Bangladesh	1010	2011	38.8	34.8	36.8	7.8 [5.1–11.5]	7.6 [2.8–15.7]	7.7 [4.8–12.0]	0.2
Lower-middle income									
India	1570	2006	43.9	43.1	43.5	12.5 [9.3–16.3]	10.0 [7.4–13.2]	11.2 [9.1–13.7]	0.3
Bhutan	2330	2010	12.3	13.4	12.8	24.4 [10.7–39.1]	24.5 [12.5–37.7]	24.4 [15.0–34.5]	2.0
Sri Lanka	3170	2012	26.8	25.7	26.3	26.5 [18.8–34.1]	16.5 [11.7–22.5]	21.7 [17.0–26.5]	1.0
Indonesia	3580	2013	19.4	20.5	19.9	25.3 [18.2–32.6]	16.1 [11.0–21.9]	20.7 [16.2–25.4]	1.3
Timor-Leste	3940	2010	43.7	46.8	45.3	16.5 [2.9–38.8]	10.2 [1.9–27.7]	13.4 [4.3–26.8]	0.4
Upper-middle income									
Maldives	5600	2009	17.2	18.4	17.8	52.5 [41.6–61.9]	29.4 [8.6–54.2]	40.7 [28.9–54.5]	3.1
Western Pacific									
Lower-middle income									
Solomon Islands	1600	2007	14.2	18.1	11.5	71.1 [62.5–78.3]	64.9 [56.3–71.9]	67.9 [62.3–72.9]	5.0
Vietnam	1740	2011	12.1	11.8	12.0	10.8 [6.4–16.9]	9.4 [5.8–14.2]	10.1 [7.1–13.9]	0.9
Papua New Guinea	2010	2011	26.7	29.0	27.9	50.3 [39.4–60.4]	45.4 [37.7–53.8]	47.8 [41.3–54.4]	1.9
Vanuatu	3130	2007	9.0	14.1	11.7	68.5 [60.6–75.7]	62.4 [53.0–69.7]	65.4 [59.1–70.7]	7.6
Philippines	3270	2011	20.3	20.1	20.2	29.1 [20.0–38.1]	24.5 [17.1–32.2]	26.9 [20.9–32.9]	1.4
Mongolia	3770	2010	4.0	5.3	4.7	49.6 [43.9–54.5]	44.4 [39.5–49.3]	47.1 [43.3–50.6]	12.4
Upper-middle income									
Fiji	4370	2004	5.7	4.9	5.3	72.9 [65.0–79.6]	60.1 [49.7–68.4]	66.6 [60.0–72.1]	12.8
China	6560	2010	3.3	3.5	3.4	24.9 [19.2–30.3]	25.1 [20.8–29.5]	25.0 [21.4–28.5]	7.5
Malaysia	10,430	2006	12.7	13.2	12.9	47.0 [39.6–54.1]	42.4 [36.5–48.8]	44.6 [39.8–49.5]	3.7
Africa									
Low income									
Burundi	260	2011	26.1	32.0	29.1	14.7 [2.3–37.3]	16.0 [3.3–37.4]	15.3 [5.0–30.7]	0.6
Malawi	270	2010	12.6	15.2	13.8	24.3 [18.7–30.2]	16.7 [12.1–22.0]	20.6 [16.9–24.8]	1.9
Niger	400	2012	37.1	38.7	37.9	16.6 [11.0–23.3]	11.0 [7.2–16.1]	13.7 [10.2–17.6]	0.4
Liberia	410	2007	18.7	21.9	20.4	27.5 [18.9–36.3]	17.7 [4.4–37.0]	22.7 [14.5–33.3]	1.5
Congo	430	2010	21.3	27.2	24.2	14.5 [9.0–21.8]	6.1 [1.9–14.0]	10.5 [6.7–15.4]	0.7
Madagascar	440	2004	34.5	39.2	36.8	8.8 [6.0–12.1]	12.6 [6.9–20.2]	10.6 [7.5–14.6]	0.3
Guinea	460	2012	15.2	17.3	16.3	20.8 [12.7–30.0]	22.2 [6.4–42.1]	21.5 [12.2–32.5]	1.4
Ethiopia	470	2011	27.3	30.9	29.2	9.0 [5.4–13.9]	7.1 [3.3–12.9]	8.0 [5.3–11.7]	0.3
Eritrea	490	2002	33.0	35.9	34.5	11.4 [6.0–19.2]	9.6 [5.3–15.3]	10.7 [6.8–15.5]	0.3
Gambia	500	2010	16.9	17.8	17.4	40.9 [26.3–57.2]	14.9 [6.8–26.2]	28.0 [19.6–37.7]	2.4
Uganda	550	2011	12.8	15.4	14.1	20.4 [13.3–28.8]	22.2 [5.6–45.4]	21.2 [12.1–33.3]	1.6
Guinea-Bissau	590	2010	17.1	19.1	18.1	26.3 [6.8–51.7]	15.3 [3.7–34.5]	21.1 [8.5–36.5]	1.5
Rwanda	630	2011	10.4	12.9	11.7	17.5 [10.8–25.5]	24.0 [6.0–47.8]	20.3 [11.1–32.0]	1.7
Tanzania	630	2011	12.9	14.2	13.6	25.8 [17.2–34.7]	22.1 [10.0–35.7]	23.9 [16.4–31.8]	2.0
Burkina Faso	670	2010	24.7	27.7	26.2	14.2 [8.0–22.2]	11.9 [4.5–23.6]	13.0 [8.0–19.8]	0.6
Mali	670	2006	26.0	29.7	27.9	25.7 [18.3–33.8]	15.3 [7.9–25.1]	21.0 [15.4–26.9]	1.0
Benin	790	2006	17.6	22.7	20.2	31.7 [25.7–38.1]	20.4 [14.9–26.3]	26.1 [22.0–30.6]	1.8
Comoros	840	2012	17.0	16.8	16.9	21.1 [9.5–35.2]	19.4 [5.3–39.4]	20.1 [10.3–32.3]	1.2

Table 1 (continued)

Region, income, and country ^a	GNI	% Underweight (age < 5 years)			% Overweight (BMI ≥ 25)–Age 20+ (95 % CI) ^c			Underweight/overweight ^d	
		Year ^b	Female	Male	Total	Female	Male		Total
Zimbabwe	860	2011	8.7	11.5	10.1	40.3 [32.3–48.6]	17.6 [10.5–25.6]	29.4 [24.0–35.3]	4.6
Chad	1020	2010	28.2	32.5	30.3	16.9 [9.8–25.4]	14.6 [6.4–25.7]	15.7 [9.9–22.6]	0.6
Kenya	1160	2009	15.5	17.3	16.4	25.5 [18.7–32.7]	15.2 [4.6–31.7]	20.5 [14.0–29.0]	1.6
Lower-middle income									
Senegal	1050	2013	15.4	18.1	16.8	37.0 [28.1–46.4]	18.0 [6.4–34.2]	27.7 [20.2–36.7]	2.4
Mauritania	1060	2012	17.2	21.8	19.5	53.9 [42.9–63.0]	22.8 [11.1–35.5]	38.7 [30.7–46.6]	3.1
Côte d’Ivoire	1450	2012	12.8	18.8	15.7	32.3 [20.8–44.1]	21.8 [10.3–35.3]	26.9 [18.6–35.7]	2.5
Sao Tome and Principe	1470	2009	12.3	16.6	14.4	42.1 [32.1–52.2]	30.9 [23.3–38.0]	36.9 [30.5–43.3]	3.4
Lesotho	1500	2010	11.1	16.0	13.5	58.1 [48.6–65.9]	17.3 [4.2–38.1]	41.0 [32.8–50.8]	5.2
Ghana	1770	2011	11.3	15.4	13.4	36.7 [32.2–42.0]	24.2 [18.8–29.6]	30.4 [26.9–34.2]	3.2
Zambia	1810	2007	13.0	16.9	14.9	26.0 [19.5–32.4]	9.1 [4.2–16.4]	17.8 [13.5–22.7]	2.0
Nigeria	2710	2013	29.0	32.9	31.0	31.2 [24.8–37.2]	26.2 [15.5–37.1]	28.8 [22.7–35.0]	1.1
Angola	5170	2007	14.6	16.6	15.6	30.7 [8.1–57.4]	20.4 [4.4–42.6]	25.8 [11.0–43.1]	2.1
Algeria	5330	2005	3.7	3.7	3.7	54.5 [42.9–64.7]	41.8 [31.5–53.0]	48.2 [40.3–55.7]	14.7
Namibia	5870	2007	16.5	18.5	17.5	44.7 [36.7–52.0]	23.3 [15.5–31.6]	34.6 [28.8–40.2]	2.7
South Africa	7190	2008	9.6	13.6	8.7	73.6 [69.5–77.1]	62.0 [56.1–66.6]	68.0 [64.6–71.0]	7.7
Botswana	7770	2008	10.2	12.1	11.2	52.3 [44.6–59.2]	18.3 [12.7–24.7]	36.2 [31.3–40.8]	5.1
Gabon	10,650	2012	5.0	7.9	6.5	51.6 [42.7–59.8]	36.5 [27.3–46.2]	44.1 [37.7–50.4]	10.3
Eastern Mediterranean									
Low income									
Somalia	n.a.	2006	31.3	34.2	32.8	24.0 [5.7–48.2]	18.9 [4.9–38.8]	21.5 [8.8–36.9]	0.8
Afghanistan	690	2004	33.0	32.7	32.9	13.6 [2.0–34.8]	10.0 [1.8–27.2]	11.8 [3.5–25.1]	0.4
Lower-middle income									
Syrian Arab Republic	n.a.	2009	8.7	11.5	10.1	69.3 [61.6–76.1]	63.4 [55.0–70.3]	66.4 [60.8–71.4]	8.0
Djibouti	n.a.	2012	28.5	31.2	29.8	37.4 [13.2–62.5]	30.2 [10.1–53.0]	33.9 [17.9–50.9]	1.3
Pakistan	1360	2013	29.1	34.1	31.6	28.8 [16.1–43.2]	20.0 [10.3–31.8]	24.3 [16.4–33.4]	1.0
Sudan	1550	2006	25.9	28.1	27.0	28.2 [7.5–53.1]	21.6 [5.9–42.0]	25.0 [10.8–40.8]	1.1
Morocco	3020	2011	3.1	3.1	3.1	53.6 [44.9–60.9]	43.1 [32.5–54.3]	48.5 [41.7–55.2]	17.3
Egypt	3140	2008	5.4	8.1	6.8	76.9 [74.1–79.6]	62.4 [53.5–69.5]	69.8 [65.2–73.6]	14.2
Upper-middle income									
Tunisia	4200	2012	1.4	3.2	2.3	64.2 [54.0–73.1]	47.5 [34.9–59.0]	55.9 [47.7–63.5]	45.9
Jordan	4950	2012	2.6	3.4	3.0	71.2 [68.3–73.8]	66.5 [61.7–71.0]	68.8 [66.0–71.4]	27.4
Iraq	6720	2011	7.4	9.4	8.5	68.2 [60.9–74.8]	62.2 [55.1–68.3]	65.2 [60.1–69.8]	9.2
Lebanon	9870	2004	2.8	5.4	4.2	58.7 [53.6–63.8]	67.0 [62.8–70.9]	62.8 [59.5–66.0]	21.0
Americas									
Low income									
Haiti	810	2012	10.7	12.5	11.6	29.4 [21.0–38.0]	35.0 [13.4–57.7]	32.0 [20.9–43.9]	2.7
Lower-middle income									
Nicaragua	1790	2007	5.9	5.6	5.7	63.2 [57.7–68.3]	53.3 [37.7–66.5]	58.4 [50.4–65.5]	10.7
Bolivia	2550	2008	4.0	4.9	4.5	58.9 [52.3–64.4]	40.4 [25.1–56.7]	50.0 [41.9–58.4]	14.7
Guatemala	3340	2009	12.1	13.9	13.0	58.6 [48.7–66.3]	48.6 [36.3–60.7]	53.9 [46.4–61.2]	4.8
Guyana	3750	2009	9.4	12.8	11.1	56.6 [31.9–76.3]	34.6 [12.7–57.7]	44.7 [28.2–60.7]	6.0
Paraguay	4010	2005	3.4	2.2	3.4	50.2 [21.8–73.5]	50.9 [26.6–72.3]	50.5 [32.0–66.9]	14.8
Upper-middle income									
Argentina	n.a.	2005	2.2	2.4	2.3	61.1 [51.2–70.1]	66.8 [58.3–74.5]	64.0 [57.5–70.0]	27.8
Belize	4510	2011	6.6	5.7	6.2	76.6 [71.0–81.6]	65.4 [57.7–71.6]	71.0 [66.1–75.2]	11.6

Table 1 (continued)

Region, income, and country ^a	GNI	% Underweight (age < 5 years)			% Overweight (BMI ≥ 25) – Age 20+ (95 % CI) ^c			Underweight/overweight ^d	
		Year ^b	Female	Male	Total	Female	Male		Total
Jamaica	5220	2010	2.6	3.8	3.2	70.6 [65.1–75.3]	40.7 [34.6–47.2]	56.2 [52.1–60.2]	27.2
Ecuador	5760	2004	6.0	6.5	6.2	60.2 [50.2–68.3]	51.8 [35.8–66.8]	56.0 [46.6–64.8]	10.0
Dominican Republic	5770	2007	3.7	3.2	3.4	61.1 [49.0–71.2]	49.6 [36.3–62.9]	55.4 [46.7–63.9]	16.5
Peru	6270	2012	3.2	3.7	3.5	52.2 [46.4–57.5]	43.3 [36.9–50.0]	47.9 [43.5–52.2]	16.3
Suriname	9370	2010	5.4	6.2	5.8	64.8 [44.7–81.0]	51.7 [29.1–70.8]	58.4 [43.6–71.6]	12.0
Costa Rica	9550	2009	1.8	0.6	1.1	58.8 [50.4–66.7]	60.3 [51.1–68.3]	59.6 [53.4–65.4]	32.7
Panama	10,700	2008	5.2	2.8	3.9	64.1 [53.5–73.8]	58.2 [47.2–68.1]	61.2 [53.5–68.5]	12.3
Brazil	11,690	2007	2.1	2.2	2.2	52.0 [46.4–57.2]	53.5 [47.1–59.9]	52.8 [48.5–56.9]	24.8
Europe									
Low income									
Tajikistan	990	2012	13.1	13.6	13.3	33.9 [17.7–49.9]	33.7 [12.1–56.8]	33.8 [20.4–47.7]	2.6
Lower-middle income									
Uzbekistan	1880	2006	4.3	4.6	4.4	47.2 [34.7–57.2]	48.9 [38.1–58.6]	48.1 [39.8–55.2]	11.0
Republic of Moldova	2470	2005	3.4	3.0	3.2	57.7 [50.3–64.5]	38.7 [14.7–62.4]	49.2 [37.4–61.0]	17.0
Georgia	3570	2009	1.0	1.3	1.1	54.8 [29.6–74.7]	50.7 [28.5–70.3]	53.0 [36.2–68.0]	54.8
Armenia	3800	2010	5.9	4.7	5.3	59.3 [52.7–65.8]	49.2 [40.2–57.3]	55.1 [49.6–60.3]	10.1
Ukraine	3960	2002	3.5	4.8	0.9	53.2 [38.6–65.0]	49.8 [26.2–70.9]	51.8 [38.1–64.1]	15.2
Upper-middle income									
Albania	4710	2009	6.0	6.6	6.3	48.2 [31.0–63.1]	60.5 [45.1–72.6]	54.2 [42.8–64.3]	8.0
Bosnia and Herzegovina	4780	2012	1.3	1.8	1.5	53.1 [43.7–61.4]	61.9 [52.7–69.7]	57.6 [51.2–63.4]	40.8
The former Yugoslav republic of Macedonia	4870	2011	1.1	1.5	1.3	46.0 [27.9–61.2]	59.6 [38.1–76.2]	52.8 [38.8–64.8]	41.8
Serbia	6050	2010	1.7	1.5	1.6	46.2 [39.2–52.6]	65.3 [60.2–69.7]	55.9 [51.5–60.0]	27.2
Belarus	6730	2005	1.0	1.5	1.3	55.6 [30.1–75.6]	56.7 [34.0–75.0]	56.2 [39.4–70.1]	55.6
Montenegro	7250	2013	1.6	2.8	1.0	48.4 [23.3–69.7]	61.3 [39.6–77.5]	54.6 [38.7–68.7]	30.3
Azerbaijan	7350	2006	8.0	8.7	8.4	61.9 [55.3–67.8]	52.0 [44.5–59.0]	57.4 [52.3–62.2]	7.7
Bulgaria	7360	2004	1.9	1.3	1.6	47.1 [36.8–56.3]	61.2 [52.6–68.3]	54.3 [47.6–60.3]	24.8
Romania	9060	2002	2.9	4.0	3.5	45.4 [31.4–57.5]	51.7 [38.3–63.3]	48.6 [39.1–57.1]	15.7
Turkey	10,970	2008	3.9	3.1	1.7	65.8 [62.1–69.4]	61.4 [57.6–64.7]	63.6 [61.0–66.1]	16.9
Kazakhstan	11,550	2011	3.6	3.7	3.7	55.9 [43.4–66.4]	57.0 [37.9–71.9]	56.7 [45.5–65.8]	15.5
Hungary	13,260	1988	1.6	2.9	2.3	49.4 [32.1–64.5]	65.8 [53.9–76.1]	57.7 [47.1–67.2]	30.9

Data from World Health Organization (WHO) Global InfoBase (<https://apps.who.int/infobase>; accessed 5 March 2015)

GNI Gross National Income per capita based on World Bank data

^a Country was grouped according to WHO region

^b Year of data available for the prevalence of overweight

^c Age-standardized estimate, based on 2008 data

^d Ratio comparing female overweight/female underweight

Overnutrition Prevalence

Overnutrition is defined as overweight (body mass index [BMI] >25 kg/m²) or obesity (BMI ≥30 kg/m²). Levels of overnutrition have increased substantially across developing countries, both in middle- and in low-income countries. The current prevalence of overweight in lower, lower-middle, and upper-middle income countries is 21.1 % (range, 7.8–40.9 %),

44.5 % (range, 10.8–76.9 %), and 55.9 % (24.9–76.6 %), respectively (Table 1 and Fig. 1). The annual increase in obesity is estimated to be 0.31 to 0.91 % [6], depending on the country’s economic growth [14, 15]. In countries with economic growth around 6 % annually, such as Indonesia, obesity has increased remarkably over the past 20 years across all population groups, including rural and low-income groups [9].

The prevalence of underweight and overweight in low, lower and middle income countries

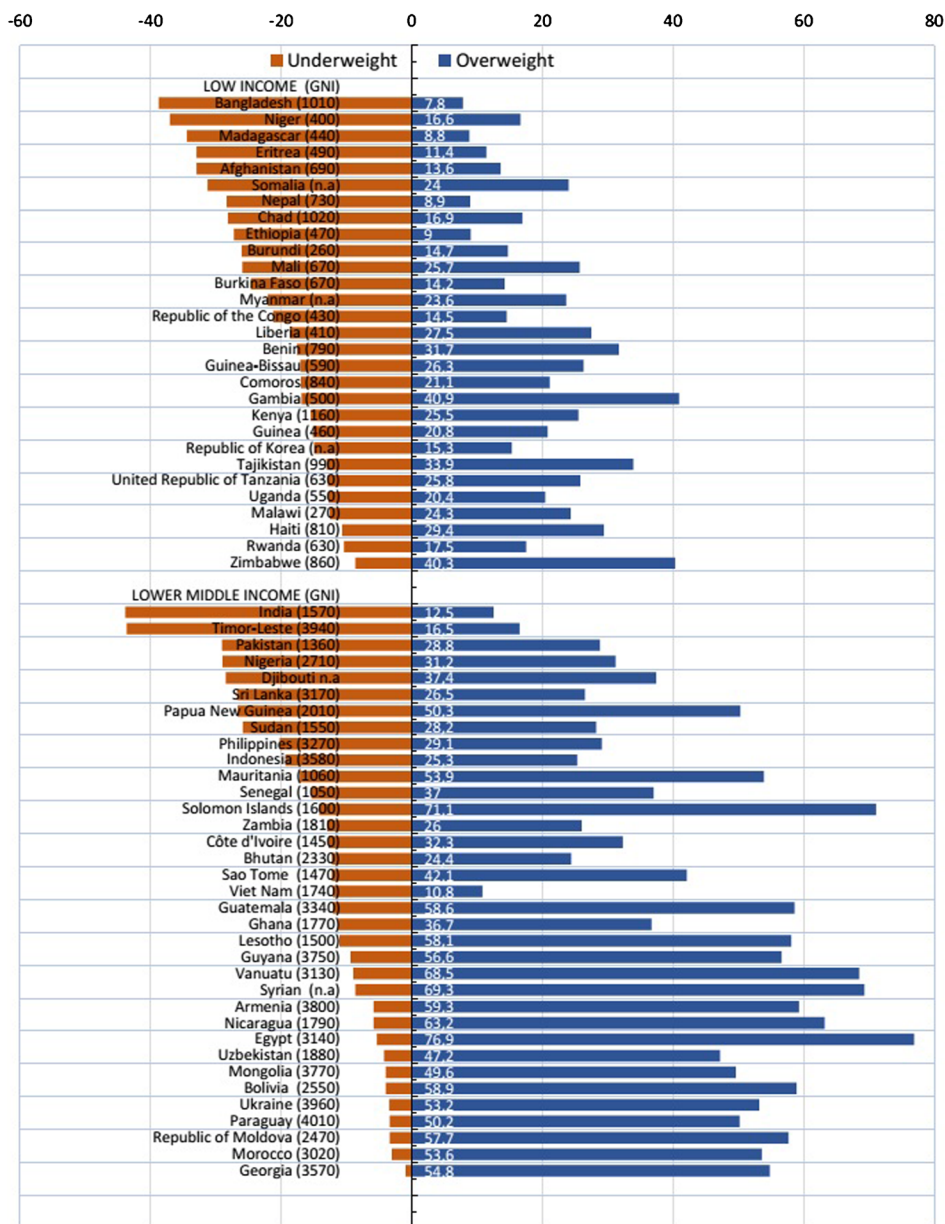


Fig. 1 The prevalence of underweight and overweight in low, lower-middle, and upper-middle income countries. Underweight of children under five (low weight-for-age according to the WHO child growth standards) and overweight of age 20+ which defined as BMI ≥ 25 kg/m²

In addition, the pattern of body weight gain in most developing countries now mimics that found in developed countries [16]. A study analysing 30 low- and middle-income countries (1991–2008) found that estimated increases in overweight prevalence over time were greater in the lowest- than the highest-wealth and highest-education groups [17, 18]. Moreover, a severe obesity problem was observed among women [9]. A study examining a 20-year trend of obesity in women in urban Colombia found that the age-standardized prevalence of obesity increased remarkably from 7.9 to 17.0 % in the lower socioeconomic status (SES) group, but only from 4.5 to 8.2 %

in the middle SES group, and was unchanged in the upper SES group [19]. In addition, the significant increase in over-nutrition no longer is exclusive to urban areas. In Indonesia, for example, maternal and child double burden (MCDB) was observed in 11 % of households in rural areas [20].

The Ratio of Double Burden

The coexistence of undernutrition and overnutrition is known as the dual burden [3••] or double burden [4] of malnutrition (DBMN) and is analysed by the ratio of overweight to

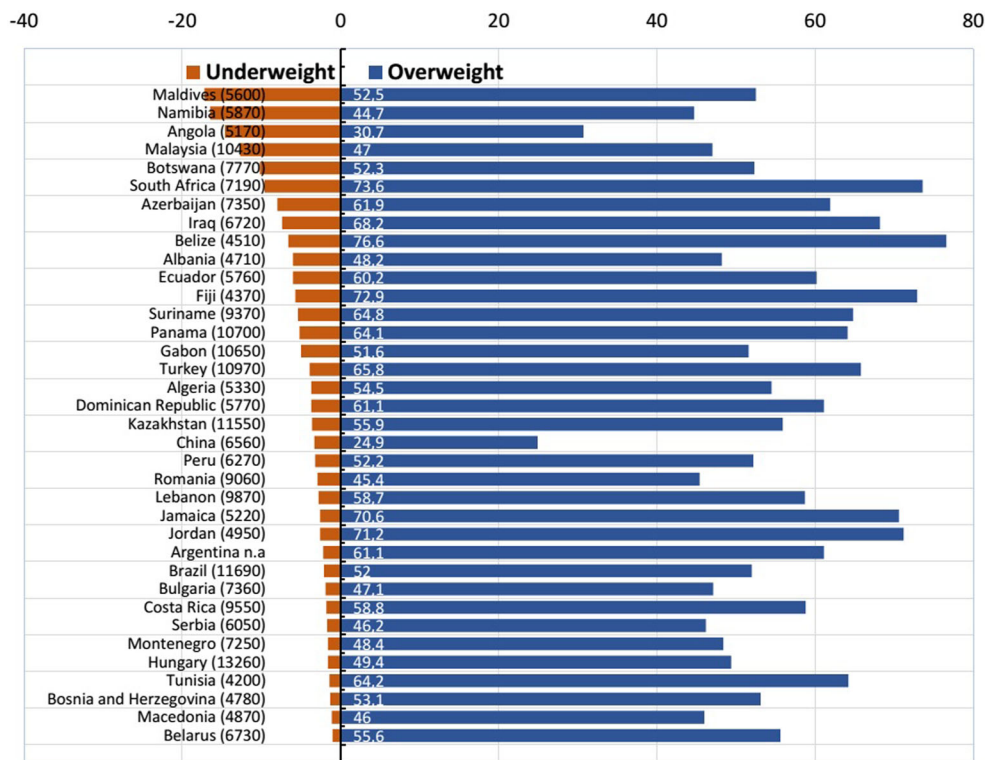


Fig. 1 (continued)

underweight. Currently, overweight is significantly more prevalent than underweight. The median ratio of overweight to underweight prevalence is 4.1; however, the ratio differs significantly (*P* value 0.0001) among income categories (low, lower-middle, and upper-middle), with a median of 1.1, 3.4, and 15.6, respectively. Among low-income nations, the number of countries with an overweight/underweight ratio greater than 1 and the number with a ratio less than 1 was almost the same (15 of 29 countries included in this analysis have a ratio >1). As the income of these countries has increased, so has the ratio of overweight to underweight (86 % of the countries in this category have a ratio >1). Among the upper-middle income countries analysed, all have a higher ratio of overweight to underweight (range, 2.1–55.6) (Table 1).

Published Studies Examining DBMN in Developing Countries

This study identified many articles analysing undernutrition or overnutrition alone but only a few analysing DBMN. A systematic search of articles published from 2007 to 2014 found only 28 analysing DBMN in developing countries. A brief overview of the studies’ characteristics is presented in Table 2, and some important features are described in the following sections. Eight articles provided a general review [1•, 3••, 4, 21–25] of DBMN but did not focus on any particular developing countries, 10 examined the situation of DBMN in the

Asia Pacific region [20, 26•, 27–34], 8 focused on DBMN in Latin American [35–42], and 2 examined the DBMN situation in Africa [43, 44].

Double Burden Overnutrition and Undernutrition Classifications

Several studies examined the three general levels of DBMN [3••, 4, 23, 30, 45], namely DBMN observed in the same population/community, in the same household/family, or in the same person/individual, depending on the latency and sensitivity windows for developing different types of malnutrition. However, the study investigators argue that an individual may experience interrelated levels of DBMN. For example, the coexistence of stunting and obesity may reflect inadequate nutrition and a poor-quality diet in the first 2 years, followed by excesses in energy intake later in childhood.

DBMN at the Community Level

Community-level DBMN usually is characterized by a prevalence of stunting and/or wasting and overweight or obesity within the community [3••]. Some segments of society, usually the poor and those of low SES in rural areas as well as the urban poor might experience stunting and underweight, whereas those who are economically better off are experiencing overnutrition. This disparity, however, currently is shifting to the poor and others of low SES [46].

Table 2 Published studies examining DBMN in developing countries

No.	Authors (year)	Focus of study	Key results	Brief conclusion and recommendation
General review studies				
1	Tzioumis and Adair (2014) [3••]	DBMN at different levels: community, household, and individual child	On the community level, economic status may influence the dual burden's extent, with obesity increasingly affecting the already undernourished poor. In a household, shared determinants of poor nutritional status among members may result in disparate nutritional status across generations. Within an individual, obesity may co-occur with stunting or anaemia because of shared underlying determinants or physiologic links.	DBMN poses a threat to children's health in low and middle income countries. It is suggested to remain committed to reducing undernutrition while preventing overnutrition.
2	Kulkarni et al. (2014) [1•]	Role of childhood undernutrition and adult-onset adiposity throughout the life course	There is a positive association between early nutritional status (indicated by birth weight and growth during first 2 years) and overweight in later life.	Promoting optimal intakes of nutrients throughout the life course is important for reducing childhood undernutrition as well as for improving the body weight of adults.
3	Cai (2014) [4]	DBMN situation in transitional societies	With rapid industrialization, developing countries are facing a growing epidemic of overweight/obesity in children and adolescents. However, stunting growth and micronutrient deficiency remain child health issues in transitional countries.	Social transition caused a broad range of nutrition-associated problems. Appropriate action is required and greater efforts are needed to improve the status of childhood nutrition in transitional countries.
4	Adair (2014) [21]	Long-term consequences of malnutrition in early life	Undernutrition during preconception, pregnancy, and infancy might be associated with obesity in later life.	Optimizing maternal nutrition before pregnancy, micronutrient adequacy in the preconception period and during pregnancy, and promotion of breastfeeding and high-quality complementary foods might prevent obesity in adulthood.
5	Yang and Huffman (2013) [22]	Impacts of maternal and early child nutrition on risk of later obesity	Poor prenatal dietary intakes of energy, protein, and micronutrients were shown to be associated with increased risk of adult obesity in offspring.	Interventions to reduce risk of obesity in later life might focus on improving maternal nutritional status during pregnancy to reduce low birth weight, enhancing breastfeeding (including durations of exclusive and total breastfeeding), timely introduction of high-quality complementary foods (containing micronutrients and essential fats)
6	Varela-Silva et al. (2012) [23]	Different types of DBMN and how to assess it	The prevalence of individual dual-burden among children is very low, but is very high among the mothers and for mother-child pairs (household dual-burden)	It is important to have standardized criteria to assess DBMN within the individual and the household.
7	Uauy et al. (2011) [24]	Developmental Origins of Health and Disease (DOHaD) paradigm and double burden of nutrition	Early malnutrition has life-course and transgenerational consequences.	Repositioning of maternal and infant nutrition is necessary not only in health and nutrition intervention programs but also in program and policy decisions.
8	Corsi et al. (2011) [25]	DBMN situation in low to middle income countries (LMICs)	The explicitly negative correlations between prevalence of underweight and overweight at the country level and neighbourhood level	Double burden has not yet occurred in a substantial manner in most LMICs.
Studies focusing on Asia Pacific region				
9	Haddad et al. (2014) [26•]	DBMN in southeast (SE)/Asia and the Pacific	Overweight rates have risen fast in the regions of SE Asia and the Pacific, which also are burdened with high and often stagnant levels of undernutrition.	DBMN has significant implications for the political agenda but also has created some opportunities for a leadership agenda within the region to address it.
10	Vaezghasemi et al. (2014) [27]	The effect of gender and social capital on DBMN	Approximately one-fifth of all households in Indonesia exhibited DBMN, which was more prevalent among male-headed households, households with a high SES, and households in urban areas.	The inclusion of women's empowerment and community social capital is required to address DBMN.
11	Lailou et al. (2014) [28]	Intra-individual DBMN among Vietnamese women	Intra-individual DBMN (overweight/obesity and micronutrient deficiency) was observed among women.	Micronutrient deficiencies are an issue across the weight spectrum among women. It therefore is essential for Vietnam to actively prevent women of reproductive age from overweight/obesity while controlling micronutrient deficiencies.

Table 2 (continued)

No.	Authors (year)	Focus of study	Key results	Brief conclusion and recommendation
12	Khan and Khoi (2008) [29]	DBMN in Vietnam	DBMN has occurred in Vietnam.	Controlling nutritional deficiencies and newly emerging nutrition problems to reduce DBMN in Vietnam requires comprehensive and appropriate measures.
13	Winichagoon (2013) [30]	Maternal and child DBMN in Thailand	During the 1980s–1990s, the prevalence of low birth weight remained stable while stunting and underweight declined. Overnutrition among women and children has affected all socioeconomic levels.	Early-life undernutrition should be considered along with measures to address obesity and chronic diseases in children.
14	Roemling and Qaim (2013) [31]	Dual burden households in Indonesia.	Sixteen per cent of Indonesian households are classified as dual burden. In these households, children often are underweight, whereas adults are overweight.	The dual burden classification has limitations in terms of capturing nutritional dynamics.
15	Khan and Talukder (2013) [32]	Nutrition transition in Bangladesh	The transition from undernutrition to overnutrition and DBMN among Bangladeshi women of reproductive age	Efforts by the Bangladesh Integrated Nutrition Programme under the first Sector-Wide Approach (SWAp) should address not only the undernutrition aspect of malnutrition but also the other form of malnutrition (overnutrition).
16	Le Nguyen et al. (2013) [33]	Double burden of undernutrition and overnutrition in Vietnam	Undernutrition was more prevalent in rural areas than in urban areas. In contrast, a large proportion of urban children were either overweight or obese compared with children in rural areas.	Information from the South East Asian Nutrition Survey (SEANUTS) may be used as an input for targeted policy development, planning, and development of nutrition programs in Vietnam.
17	Oddo et al. (2012) [20]	The prevalence of DBMN and its predictors in Indonesia and Bangladesh	Maternal and child double burden (MCDB) was observed in 11 % and 4 % of the households in rural Indonesia and Bangladesh, respectively.	Double burden is not exclusive to urban areas. Therefore, future policies and interventions should address undernutrition and overweight simultaneously in both rural and urban settings in developing countries.
18	Shafiqe et al. (2007) [34]	Trends of double burden in rural and urban poor women in Bangladesh	The prevalence of chronic energy deficiency continues to be a major nutritional problem among Bangladeshi women in rural and poor urban areas. In addition, urban poor and rural women were found to be at risk for overweight. The risk of being overweight was higher among women who were older and of higher SES.	The recent increase in overweight prevalence among both urban poor and rural women indicates the emergence of DBMN in Bangladesh.
Studies focusing on Latin America				
19	Rivera et al. (2014) [35]	Reviewed DBMN in Latin America	Chile has the lowest prevalence of stunting, whereas Guatemala has the highest prevalence, followed by Ecuador, Colombia, Mexico, Uruguay, and Brazil. Prevalence of overweight (>7 %) in children <5 years is found in Chile, Uruguay, Mexico, Ecuador, and Brazil, whereas prevalence is lower in Guatemala and Colombia.	Policies and programs are needed to tackle both conditions simultaneously in a coordinated fashion. The policies and programs should centre around the notion of “healthy eating” and “healthy lifestyles” during the different phases of the life course.
20	Sarmiento et al. (2014) [36]	The DBMN situation in Colombia	Double burden coexists at the national, household, and intraindividual levels in Colombia.	Public policies should address double burden conditions through multiple strategies, and the current nutrition policies should be evaluated.
21	Severi and Moratorio (2014) [37]	Double burden of undernutrition and obesity in Uruguay	Double burden of nutritional problems exists in Uruguay.	This nutritional burden in Uruguay is similar to that of other countries in the region. This important public issue should be tackled, and it should be addressed in early infancy.
22	Kroker-Lobos et al. (2014) [38]	The double burden of undernutrition and excess body weight in Mexico	The prevalence of double burden was significantly lower than expected, whereas anaemia and the prevalence of overweight or obesity in women were not different from that expected.	The coexistence of stunting, overweight or obesity, and anaemia at the national, household, and intraindividual levels in Mexico calls for policies and programs to prevent the 3 conditions.
23	Ramirez-Zea et al. (2014) [39]	DBMN in indigenous and nonindigenous Guatemalan populations	Between 1998 and 2008, the prevalence of childhood stunting decreased in both indigenous and nonindigenous populations, whereas overweight and obesity in women increased faster in indigenous populations than in nonindigenous populations.	DBMN is more prevalent in indigenous than in nonindigenous populations at the household and individual levels.
24	Freire et al. (2014) [40]			

Table 2 (continued)

No.	Authors (year)	Focus of study	Key results	Brief conclusion and recommendation
		The double burden of undernutrition and excess body weight in Ecuador	The coexistence of high rates of undernutrition and overweight/obesity at the individual, household, and national levels in Ecuador	Integrated approaches to address the emerging double burden are required; public health policies to date have not responded adequately.
25	Conde and Monteiro (2014) [41]	Nutritional transition and double burden of undernutrition and excess weight in Brazil	In Brazil, the current prevalence of excess weight is at least threefold higher than that of undernutrition.	Inclusive social policies have succeeded in reducing poverty and in identifying new challenges related to obesity control or reduction.
26	Chaparro and Estrada (2012) [42]	Nutritional transition in each department within Peru	High rate of stunting among children and high rates of overweight and obesity among women of reproductive age	Decentralized nutrition policies are required according to what types of malnutrition exist in each geographic area
Studies focusing on Africa				
27	Sleyn and McHiza (2014) [43]	DBMN transition in sub-Saharan Africa	Overweight increased in nearly all sub-Saharan African countries.	Health interventions are urgently needed in countries in the early stages of nutritional transition.
28	Vorster et al. (2011) [44]	Nutritional transition related to nutritional intake changes	There is a putative epigenetic link between undernutrition and overnutrition, explaining the double burden of nutrition-related diseases in Africa.	Some possibilities exist to steer the nutritional transition into a more positive direction.

DBMN in a Household

Household-level DBMN occurs in a household in which at least one member is underweight and at least one is overweight [3••]. It is characterized by the presence of a stunted child/overweight mother [47–49] or an overweight child/underweight adult in the household [50]. The coexistence of a stunted child and an overweight mother in the same household (SCOWT) in the developing world is a distinct [49] or paradoxical phenomenon [48]. One study argued that SCOWT increases with economic development up to a point [48]. As a family's income increases, the adults adopt increasingly sedentary lifestyles and can afford more energy-dense but nutrient-poor foods for their household. This contributes to increased overweight in adults but a failure to meet linear growth potential in children [3••]. This phenomenon is most prevalent in countries in the midst of a nutritional transition or in the middle range regarding gross national product (GNP) [51].

DBMN Within an Individual

DBMN within an individual child often manifests as stunting or micronutrient deficiencies co-occurring with overweight or obesity [3••]. The child might have low height for age (chronic undernutrition) accompanied by high weight for age (obesity) [52], i.e., be “short and plump” [53]. The reason for this is unclear: If there is enough energy for a child to gain excess weight, then why does the child fail to reach his or her linear growth potential and become stunted [3••]? Some studies suggest that it might be related to diet composition and quality [3••, 54]. Usually, DBMN within an individual involves two types of nutrient deficiencies: type I or type II deficiency. Type I deficiency (i.e., iron and vitamin A) results in a depletion of body nutrient stores but maintenance of linear growth, and type II nutrient deficiency (i.e., zinc and protein) results in decreased linear growth [54].

Some studies have associated this phenomenon with genetics, including the popular theory of “thrifty genes” originally proposed by Neel [55]. The fundamental basis of the thrifty gene hypothesis is that early in human evolution, genes promoting efficient fat deposition were advantageous because they allowed one to survive during periods of famine. Recently, however, the fundamental assumptions of this hypothesis have been criticized, because famines affect not only survival but also fecundity; therefore, obese people would be expected to sustain fecundity longer in the face of food shortages. In the 50 or so years since Neel [55] proposed the thrifty gene hypothesis, no one has discovered any convincing candidates for these genes. Recently, Speakman [56] argued that famines provide insufficient selective advantage over an insufficient period for a thrifty gene to have any penetration in the modern human population. In his papers, Speakman [56–58] strongly

proposed an alternative scenario, the “drifty gene” hypothesis, which posits that subsections of the population have a genetic predisposition to obesity because of an absence of selection, combined with genetic drift. However, both the thrifty gene and drifty gene theories assume that the selection pressures faced by modern humans are the same as those of their ancestors. In a study published in 2014, Sellayah et al. [59] pointed out that neither theory adequately explains the impact of economic growth in developing countries and changing population demographics on the genetic basis for obesity, despite clear evidence for ethnic variation in obesity susceptibility and related metabolic disorders. Therefore, they theorize that the current obesity pandemic in both developed and developing countries is a result of differences in environmental exposures among the ancestors of modern humans.

DBMN over the Life Course

In addition to the common driving factors of rapid economic growth, urbanization, and changes in diet styles in developing countries [4, 60], the factor of malnutrition over the life course has been associated with the increasing prevalence of DBMN in developing countries [1•, 21, 22, 24, 30, 43]. This argument is supported by several studies. Recently, Kulkarni et al. (2014) [1•] identified many studies in developing countries showing an association between nutrition in early life and body composition in later life [61–68]. Poor prenatal dietary intakes of energy, protein, and micronutrients were significantly associated with an increased risk of adult obesity in offspring [22]. Stunted children have a higher risk of obesity later in life [5]. Therefore, the life-course approach to malnutrition emphasizes two theoretic models in which exposure to risk factors (i.e., undernutrition) during a critical period or developmental programming might have gradual and long-term cumulative effects on health (i.e., obesity) [46, 69]. Many leading scientists, economists, and health experts agree that improving nutrition during the critical period (i.e., the first 1000 days of life) is one of the best investments for achieving lasting progress in global health and development. These efforts include an emphasis on optimizing maternal nutrition prior to pregnancy, micronutrient adequacy in the preconception period and during pregnancy, and promotion of breastfeeding and high-quality complementary foods [21], and should be considered along with measures to address obesity [30]. However, some critics have raised concerns regarding several current nutritional programs in the developing world that might exacerbate the problem of obesity, such as the initiative to improve complementary feeding with fortified products. Therefore, it is challenging for many developing nations to institute integrated child health programs that can reduce the prevalence of undernutrition while preventing overnutrition [3••].

Conclusions

An analysis of the prevalence of underweight and overweight in 100 developing countries suggests that DBMN already exists in almost all developing countries. In only a few low-income countries is the prevalence of underweight still greater than that of overweight. Many studies show that DBMN clearly manifests within communities, households, and individuals in most developing countries. The sharply increasing prevalence of overweight in most developing countries has led many researchers and policy makers to question the impact of maternal and early childhood nutrition on the risk of obesity later in life. Rapid economic growth, urbanization, and change in diet styles are not the only risk factors driving the increase in overnutrition in developing countries. Poor nutrition in early life also has been considered a major factor in increasing obesity rates in these nations. Countries that now have a higher prevalence of undernutrition (i.e., stunting, wasting, and micronutrition) will be at higher risk for an increased prevalence of obesity in the next decades. It appears that without an integrated initiative to reduce undernutrition while preventing obesity, DBMN will become a silent factor in noncommunicable disease and new threat for health systems in developing countries. A life-course approach emphasizing the importance of early-life nutrition should be considered as an alternative measure to address obesity in the future. Improving nutrition during the critical period of the first 1000 days of life may be a promising strategy for overcoming DBMN in developing countries.

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Compliance with Ethics Guidelines

Conflict of Interest Asnawi Abdullah declares that he has no conflict of interest.

Human and Animal Rights and Informed Consent This article does not contain any studies with human or animal subjects performed by the author.

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