Coll. Antropol. **36** (2012) 1: 39–45
Original scientific paper

The Nutritional Dual-Burden in Developing Countries – How is it Assessed and What Are the Health Implications?

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A B S T R A C T

This paper focuses on the phenomenon of the nutritional dual-burden in the developing world. Nutritional dual-burden is defined as the coexistence of under-and-over nutrition in the same population/group, the same household/family, or the same person. In this paper we aim: a) to describe the different types of nutritional dual-burden, b) to identify the anthropometric indicators generally used to classify the nutritional dual-burden, c) to focus our attention on a dual-burden group (the Maya from Merida, Yucatan, Mexico), d) to illustrate problems in the categorization of the dual-burden, and e) to suggest possible health implications. Our results show that, for our sample, 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). Most importantly, the criteria used to assess the nutritional status of the individuals and of the families will play an important role in the estimated prevalence of nutritional dual-burden, and this will have practical impacts for health intervention programs.

Key words: *nutritional dual-burden, stunting, underweight, overweight, obesity, Maya, Mexico*

Introduction

The nutritional dual-burden can be broadly defined as the coexistence of undernutrition (mainly stunting) and overnutrition (overweight and obesity) in the same population/group, the same household/family, or the same person. This phenomenon is mainly seen in developing countries[1–3] and it is sometimes referred to as the »double burden of malnutrition«[4], the phenomenon of »under- and over-nutrition«[5,6], and the »short-and-plump syndrome«[7].

The nutritional dual burden was rarely recognized as a problem before the 1980s. Adrianzen et al.[8] reported the phenomenon without naming it. In a study among extremely poor families living in the slums of Lima, Peru, they found »…underdevelopment in height, starting in infancy, but relatively the opposite for weight. Most of these children actually look short and chubby, leading casual observers to think them healthy and well-nourished« (pp. 928). Martorell et al.[7,9] described the »short-plump« syndrome of Mexican-American children in the United States and Trowbridge et al.[10] did the same for Peruvian children with high weight-for-height. A few years later Smith et al.[11], and Markowitz and Cosminsky[12] reported the problem of short-stature combined with overweight among other migrant groups in the USA. At the regional level, in the Yucatan, Dickinson[13] also reported evidence of the existence of dual-burden adults.

The nutritional dual-burden of short stature and overweight is an unexpected phenomenon in human biology as it is not predicted by traditional understandings of human nutrition and its effects on human growth. Some relatively rare cases of stunting are associated with a deficiency in a specific essential nutrient, such as iodine. Genetic syndromes, such as Down's or Prader-Willi, result in short stature with over-fatness. However, in the general population the causes of stunting are usually associated with a total reduction in food intake, often combined with infectious disease and heavy physical labour[14]. This combination should, in principle, result in a defi-

Received for publication November 8, 2011

ciency of energy and a reduced body size in both height and weight. The coincident existence of stunting and overweight in communities, families and individuals is, therefore, surprising on metabolic, auxological, and thermodynamic principles. A deep and detailed analysis is needed to identify the components and the health implications of this nutritional paradox.

The aims of this paper are: a) to describe the different types of nutritional dual-burden, b) to identify the anthropometric indicators generally used to classify the nutritional dual-burden, c) to focus our attention on a dual-burden group (the Maya fromMerida, Yucatan, Mexico), d) to illustrate problems in the categorization of the dual-burden, and 5) to suggest possible health implications.

Types of nutritional dual-burden

Figure 1 presents a schematic view of the different types of nutritional dual burden: at population/group level, at the household/family level and, at the individual level.

The nutritional dual burden at the population/group-level is characterised by a high prevalence of stunting and/or underweight coexisting with a high prevalence of overweight and/or obesity (OW/OB), within a population or a specific group[15,16]. We define »high prevalence« here as any value greater than the expected prevalence of 15% for OW/OB and 5% for stunting based upon the range of heights and BMIs in the reference or standard populations. This phenomenon is seen mainly in parts of the world undergoing the nutritional and epidemiological transitions[3,16,17]. Under these circumstances, infectious diseases are declining but are not yet at the level of developed countries and the less well-off segments of the population still suffer from them. At the same time, the nutrition transition is occurring leading to an increase in the consumption of high energy, but low nutrient quality, foods along with a reduction in physical labour that leads to an increase in the levels of overweight and obesity[4,6,18–27].

The nutritional dual-burden at the household level occurs when there is, at least, one undernourished (stunted or underweight) member and one overnourished

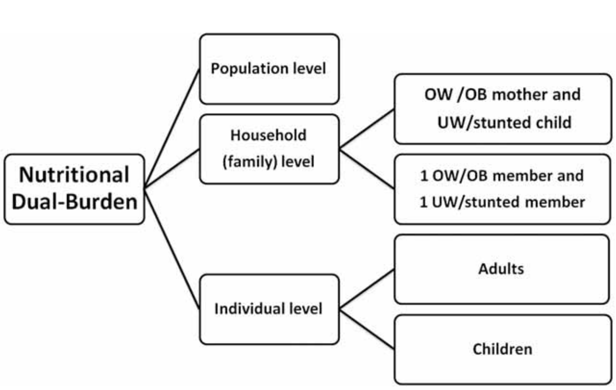

Fig. 1. Types of nutritional dual-burden; OW/OB – Overweight/ obese; UW – Underweight.

(overweight/obese) member in the household. In most of these cases there is an undernourished child living with an overweight/obese mother[5,15–17,26,28–30].

The WHO[31] has identified this phenomenon at the population and household level, stating that, »Many low- and middle-income countries are now facing a 'double burden' of disease.While they continue to deal with the problems of infectious disease and under-nutrition, they are experiencing a rapid upsurge in non-communicable disease risk factors such as obesity and overweight, particularly in urban settings. It is not uncommon to find under-nutrition and obesity existing side-by-side within the same country, the same community and the same household. Children in low- and middle-income countries are more vulnerable to inadequate pre-natal, infant and young child nutrition At the same time, they are exposed to high-fat, high-sugar, high-salt, energy-dense, micronutrient-poor foods, which tend to be lower in cost. These dietary patterns in conjunction with low levels of physical activity result in sharp increases in childhood obesity while undernutrition issues remain unsolved«.

In the research and public health statements cited in this WHO factsheet there is no mention of the nutritional dual-burden at the individual level. This level of dual-burden can be subdivided in two types: type 1 is a nutritional dual-burden among adults, and type 2 is a nutritional dual-burden among children. Type 1 dual--burden adults were undernourished infants and children with impaired linear growth resulting in adults with very short stature. Most likely, the nutrition transition is the main contributor to their current overweight/obese status[32]. However, other factors may be also at work. For example, Florêncio et al.[33] assessed the food consumption by a very low income group of stunted adults in Brazil and concluded that the consumption *per se* did not account for the high prevalence of obesity among these individuals. This means that probably some metabolic effects related to substrate utilization[1,34,35] may also be at work. These metabolic effects may cause these individuals to preferentially store energy as fat[36], rather than use it for other purposes. Reduction in the resting energy expenditure (REE) in undernourished individuals has also been suggested as another possible mechanism to explain the increased risk for adiposity. Well--nourished adults have shown consistently reductions in REE after semi-starvation periods in experimental studies[37]. However, studies in chronically undernourished children are scarce and their results do not confirm this hypothesis[34,35,38]. Besides this, Sawaya et al.[39] suggest a model in which decrements in insulin-like growth factor (IGF-1) as a result of chronic low energy intake lead to high rates of cortisol to insulin hormones. High levels of cortisol have been associated to central obesity. Previously, Sawaya et al.[40] demonstrated that girls with lower levels of IGF-1 show less linear growth in 22 months follow-up than girls with high levels of IGF-1.

The type 2 nutritional dual-burden, among children, is difficult to understand because, theoretically, if there is enough energy for a child to get fatter, then that energy should also be used for adequate linear growth.These children may have enough calories to get fatter, but lack one or more micro-nutrients required for skeletal growth and will therefore show an impaired linear growth trajectory[41]. Also, some previous research conducted by Spurr and Reina[42], and Walker et al.[43] show that among previously malnourished children, the effects of any food supplementation will impact the growth of muscle and fat mass but not linear growth. Another possible explanation for this is because the studies that look at stunted and overweight children tend to look at this phenomenon during childhood (between 3 and 6 years of age according to Bogin[14]). However, linear growth is likely most damaged when the most rapid time for growth happens, during infancy (0–3 years of age). After that, even with adequate nutrition the velocity of growth needed to catch up takes some time or may not be available beyond the infancy. Therefore, longitudinal data are needed to truly understand what is happening in these cases in terms of linear growth impairment. Cross sectional studies tend to capture the under/over phenomenon at one point in time, but then lack information about what happens it the future. For example, Cameron et al.[44] showed that stunted 2 year olds had relatively high BMI values, but that those same children were not more likely to be overweight at 9 years. As a result the overweight status was transient in infancy.

The anthropometric indicators and criteria used to identify the phenomenon of nutritional dual-burden vary depending on whether we are dealing with children or adults. As shown in Figure 2 the criteria for defining undernutrition in children distinguishes three types: stunting or chronic malnutrition, defined as a very short height-for-age; underweight defined as a very low weight-for-age; and wasting or acute malnutrition defined as a very low weight-for-height. Wasting is an indicator of recent changes in the nutritional status due to sudden disease or unexpected shortage of food and does not contribute very much for the nutritional dual-burden phenomenon. Most studies assess these three indicators of

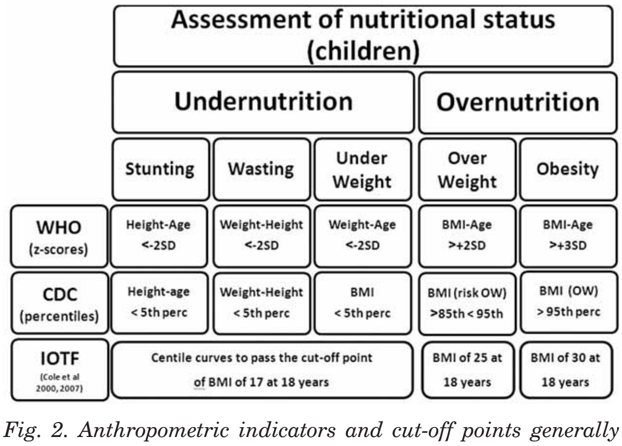

Fig. 2. Anthropometric indicators and cut-off points generally used to assess nutritional status. From these, indicators of nutritional dual-burden can be constructed.

childhood nutrition status via use of the growth reference databases of the National Center for Health Statistics (NCHS) or the growth standards and references of the World Health Organization (WHO).

The relationship between negative health outcomes and short stature is linear[45,46], therefore, this lack of biologically driven cut-offs, lead to the definition of stunting to be decided by the researcher. For children, z-scores or percentiles are preferred and statistical cut-offs based upon reference or standard growth charts are the norm. Childhood stunting is most commonly defined as a height-for-age below –1.65[47] or –2 z scores[48]. One can also use the 5th percentile of a growth chart, which is one of the least conservative cut-offs, classifying the most individuals as stunted.

The WHO and CDC recommendations are utilized primarily for the classification of children, though they can be applied to adults as well[49]. For adults, raw heights are often used, though the cut-offs become more arbitrary. For adult women, researchers working in Latin America have repeatedly used 150cm as the cut-off for stunting[50,51], which corresponds to a z-score of –2.011 and –2.051 and the 2.215 and 2.014 percentile of the WHO and CDC references, respectively. However in more well-nourished populations, such as in Europe, the 10th percentile has been used, equating to 157cm for women[52]. Less attention in the literature has been paid to stunting in adult men as short stature does not physically limit a man's child bearing ability as it does for women[53].

The criteria to define underweight among children is based on the indicators of weight-for-height. The WHO uses the cut-off point of –2 z-scores and the CDC the 5th percentile (equivalent to –1.65 Z-scores). Recently, Cole et al.[54] published BMI age-and-sex specific cut-offs for thinness in children and adolescents, scaled to equate to an adult BMI below 18.5 kg/m^2. Among adults the definition of underweight is based on a Body Mass Index (BMI) value lower than 18.5 kg/m^2.

The definition of overweight and obesity is a somewhat more complicated when assessing children. For quite a while the CDC avoided categorizing children as »obese«. Instead they used the classification of »at risk for overweight or overweight« if the child's BMI-for-age was equal or greater than the 85th percentile but lower than the 95th percentile, and »overweight« if the BMI-for-age was equal or greater than the 95th percentile. In June 2010, the CDC changed the terminology for childhood overweight and obesity, and now a child is classified as »overweight or obese« if his/her BMI-for-age falls between the 85thand the 94.9th percentile; and »obese« if his/her BMI-for-age is equal or greater than the 95th percentile[55]. Alternatively, Cole et al.[56] proposed definitions of child overweight and obesity based on cut-off points that are age and sex specific.These cut-off points are developed from longitudinal growth studies from several countries using appropriately weighted statistical models and these constitute the reference values used by the International Obesity Task Force (IOTF).

For adults, a BMI equal or greater than 25.0 kg/m^2 defines adult overweight and a BMI value equal or greater than 30.0 kg/m^2 defines adult obesity.

These different classifications of underweight and overweight/obese, as well as the use of different reference databases and growth standards, complicate the process of the dual-burden classification, the comparison of results between studies and the understanding of its health implications.

In this paper we will illustrate this problem by using a sample of urban-living mother-child pairs of Maya ethnicity and by classifying them using the different nutritional status classifications. We will then compare the dual-burden prevalence and will elaborate on the possible health and policy implications of these differences in prevalence rates caused by different assessments.

Methods

Sample

Our research project focuses on a group of urban Maya in Mérida, Yucatan, Mexico. We conducted fieldwork in the southern part of Mérida between February and July 2010 and assessed 58 mother-child pairs (Table 1). The mean age of the children was 8.42±0.79 and the mothers' was 34.30±6.28.

The Maya is a Mesoamerican civilization with thousands of years of history. Lizama[57] (p. 138) describes the Maya as »…a set of individuals who self-identify and are identified as the descendants of Mesoamerican people inhabiting the [Yucatan] Peninsula from long ago and who own, maintain and store a specific culture that differentiates it from the Mexican mestizo«. Historically the Mayan population of Yucatan has been living in conditions of chronic poverty and marginalization. More recently factors such as the rural-to-urban migration and policies of incorporation to the national and global economy, have transformed the living conditions of Mayan people[58]. Merida became, during the last decades, an important place of destination for rural-to-urban migrants.

Anthropometric measurements and reference database

Height and weight were collected from the mother-child pairs using standardised procedures[59]. Body mass index (BMI=kg/m^2) was calculated. The comprehensive reference database organized by Frisancho[47], based on the NHANES III survey, was used as the criteria for comparison for all anthropometric measurements.

TABLE 1
CHARACTERISTICS OF THE SAMPLE

Children	N	X age	SD	Minimum	Maximum
Boys	31	8.29	.84	6.82	9.95
Girls	27	8.56	.72	6.95	9.95
Total	58	8.42	.79	6.82	9.95
Mothers	58	34.30	6.28	22.52	49.42

Nutritional status indicators

Child stunting was both defined by the WHO criteria (below the –2 z-scores of height-for-age) and by the CDC criteria (below the 5th percentile of height-for-age). Child underweight was defined by both the WHO criteria (below the –2 z-scores of weight-for-age) and by the CDC criteria (below the 5th percentile of weight-for-age). Thinness was also classified using Cole et al.[54] sex- and age-adjusted centile curves. Child overweight was defined as a BMI-for-age above +2 z-scores based upon the WHO guidelines, as between the 85th and 95th percentile of BMI-for-age based upon the CDC guidelines and also the IOTF criteria was used, which are based on sex-and-age adjusted centile curves estimated to pass the cut-off point of BMI of 25 by 18 years[56]. Child obesity was defined as a BMI-for-age above +3 z-scores, as a BMI above the 95th percentile and also based on sex-and age adjusted centile curves estimated to pass the cut-off point of BMI of 30 by 18 years[54].

Maternal stunting was defined by the WHO criteria (height-for-age below –2 z-scores) and by the CDC criteria (below the 5th percentile). Maternal underweight was defined as a BMI-for-age below 18.5 kg/m^2. Maternal overweight was defined as a BMI-for-age above 25 kg/m^2 and maternal obesity was defined as a BMI-for-age above 30 kg/m^2.

A dual-burden person was defined as somebody showing a coexistence of stunting and overweight/obesity. A dual-burden mother-child pair was defined as having an undernourished child (stunted or underweight) with an overweight/obese mother.

Statistical techniques

Descriptive statistics were used for basic characterization of the sample, and chi-square testswere used to compare the prevalence of under-and-over nutrition, individual dual-burden, and mother-child dual-burden when using different nutritional status classifications.

Results

Table 2 shows the differences in the prevalence of child and maternal stunting, underweight, overweight and obesity based on the cut-off points of the WHO (z-scores), CDC (percentiles) and IOTF.

There are very few cases of childhood underweight in this sample, regardless of the criteria used to assess it. Childhood stunting doubles when it is assessed by percentiles in comparison to when it is assessed by z-scores. Childhood overweight has the lowest prevalence when assessed by z-scores (8.6%), an intermediate prevalence when assessed by percentiles (12.1%) and shows the highest value when assessed by the IOTF cut-off points (17.2%). Childhood obesity has a prevalence of zero when assessed by z scores, an intermediate prevalence when

TABLE 2
DIFFERENCES IN THE PREVALENCE (%) OF CHILD AND MATERNAL STUNTING, UNDERWEIGHT, OVERWEIGHT AND OBESITY BASED ON THE CUT-OFF POINTS AND TYPES OF ASSESSMENT OF THE WHO, CDC AND IOTF. CHI-SQUARE TESTS PERFORMED

	Children				Mothers		
	WHO	CDC	IOTF	p-value	WHO	CDC	p-value
Stunting	15.5	31.0	N/A	<0.001	55.2	81.0	<0.001
Underweight	1.7	5.2	6.9	Ns	0.0		N/A
Overweight	8.6	12.1	17.2	<0.001	91.4		N/A
Obesity	0.0	15.5	10.3	<0.001	39.7		N/A

assessed by the IOTF cut-off points (10.3%) and shows the highest value when assessed by percentiles (15.5%). Maternal stunting is also significantly higher (81.0%) when assessed by percentiles than when assessed by z-scores (55.2%).

In Table 3 we show the results of the individual dual-burden (in both children and mothers) after aggregating the nutritional status indicators according to the different assessment criteria (WHO, CDC and IOTF). We also present results of the nutritional dual-burden among mother-child pairs (one stunted child cohabiting with an overweight/obese mother).

The results show a very low prevalence of individual dual-burden among the children, with a non-significant trend to increase when percentiles are used instead of z-scores. The prevalence of individual dual-burden among the mothers is high. Half of the mothers are categorised as dual-burden individuals when assessed by z-scores and this percentage increases to 74.1% when percentiles are used.

There were no cases of household dual-burden when the child was underweight and the mother was OW/OB. The only household dual-burden combination found at mother-child pair levels was the stunted child and the OW/OB mother. When we assess dual-burden at the mother-child level we see again a significant increase in the prevalence when percentiles (27.6%) are used instead of z-scores (15.5%).

TABLE 3
DIFFERENCES IN THE PREVALENCE (%) OF DUAL-BURDEN CHILDREN, DUAL-BURDEN MOTHERS AND DUAL-BURDEN MOTHER-CHILD PAIRS BASED ON CUT-OFF POINTS AND TYPES OF ASSESSMENT OF THE WHO, CDC AND IOTF. CHI-SQUARE TESTS PERFORMED

	Dual-burden children	Dual-burden mothers	Dual burden mother-child pairs
Stunted and OW/OB (z-scores)	1.7	50	15.5
Stunted and OW/OB (percentile)	3.4	74.1	27.6
Stunted (z-scores) and OW/OB (IOTF)	1.7	N/A	N/A
Stunted (percentiles) and OW/OB (IOTF)	3.4	N/A	N/A
p-value	ns	<0.001	<0.001

Overall, these results show that using height-for age percentiles will include more individuals (both children and mothers) in the »stunted« category. Using the IOTF cut-off points for BMI in children will increase the prevalence of overweight when compared with the use of z-scores or percentiles.

Discussion

Both short stature and overweight/obesity have negative health consequences, and this compels human biologists, epidemiologists, nutritionists, and others to seek both the causes of the nutritional dual-burden and the treatments to reduce its costs to individuals, their families, and their communities. However, our data show that a considerable number of individuals may be included or excluded from the definition of dual-burden depending on the criteria used. Using the CDC criteria to define stunting (below the 5^{th} percentile of height-for-age) will classify more individuals as stunted when compared to the criteria used by the WHO (below –2 z-scores of height-for-age). This is because the 5^{th} percentile corresponds to a z-score of –1.659, the 85^{th} percentile equates to a z-score of +1.030 and the 95^{th} percentile equals a z-score of +1.640 in a statistically normal population. In a well-nourished population, the differences in number of individuals classified using z-scores *versus* percentiles may be negligible, but in a transitioning population this difference may be very large. A large portion of this sample of urban Maya (15% of the children and 25% of the mothers) has height-for-ages between –2SD and the 5^{th} percentile. Thus the interpretation of the health of the sample is heavily influenced by the criteria used for classification.

No studies have yet shown the health impacts of these differences. We suggest that a biocultural approach is needed when defining the criteria to be used in the data analysis. The criteria should depend on the research questions and also the implications for intervention. For example, if an intervention component is included in the research project, to improve the nutritional status of the individuals and the communities; shall we use the more inclusive criteria – i.e. the CDC criteria when assessing stunting and the IOTF criteria when assessing overweight/obesity? Can this strategy lead to negative consequences like stigmatising somebody to be overweight, who is not at risk or trying to improve the height of somebody who is growing within their own normal trajectory?

Our findings also raise other questions that need to be answered. These questions include: 1) are dual-burden families in poorer health than families with only stunted and/or underweight-only or families with only OW/OB?, and 2) is there a cumulative negative effect of the nutritional dual-burden that is worse than stunting or OW/OB alone? A call for more longitudinal studies is imperative to fully understand what the long term implications are when using the different definitions. We simply do not know what the risks are for populations in transition. It could be that overweight and obesity at lower levels is more risky for health – as the Indian studies have shown for Asian and Pacific populations – and in that case the recommendation to use the lower cut-off of 23.0 kg/m^2 and 27.5 kg/m^2 for overweight and obesity would be more adequate[60].

We recommend that researchers think about what is likely to occur depending on outcome. If there are limited resources for intervention then targeting the most risky children and using the cut-offs that only include those most at risk would be a good strategy. If there are more resources available then using the cut-offs that classify more individuals as at risk might be more sensible so that the individuals with borderline values do not get missed –as long as the interventions do not bring unnecessary stigmatisation to individuals.

It has been assumed than stunting after infancy (after 3 years of age) is irreversible[60]. If this is correct, than any interventions during childhood should focus only on the OW/OB side of the nutritional-dual burden in order to improve health outcomes and prevent illness in the future. However, a recent paper by Godoy et al.[61] shows that catch-up growth among stunted Amazonian Bolivian children may occur throughout the entire pre-pubertal period.The biological and cultural mechanisms underlying the catch-up growth have not been determined as yet. This reinforces the need to conduct further research among dual burden families and individuals using longitudinal studies.

Conclusions

The nutritional dual burden is now found in communities, families and individuals around the world. The cause of the nutritional dual burden may be due to a rapid change in diet composition, physical activity levels, metabolic impairments, intergenerational and developmental factors as well as familial and socioeconomic influences. We find that among a group of mother-child Maya from Merida, Yucatan, Mexico the prevalence of individual dual-burden among children is very low but is very high among the mothers and for mother-childpairs. Most importantly, the criteria used to assess the nutritional status of the individuals and of the families will play an important role in the reported prevalence of nutritional dual-burden, and this will have practical impacts for health intervention programs. Furthermore, there is still much research needed to understand whether there are additional impacts on health for those with dual burden compared to those who have the burden of a single poor indicator of poor nutrition.

Acknowledgements

We thank Adriana Vázquez-Vázquez and Jenice Tut-Be for their collaboration during the entire duration of the fieldwork. This research project has been funded by the Wenner-Gren Foundation: #ICRG-93.

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DVOSTRUKI TERET PREHRANE U ZEMLJAMA U RAZVOJU – KAKO SE ODREĐUJE I KOJE SU ZDRAVSTVENE IMPLIKACIJE

S A Ž E T A K

Naglasak rada je na fenomenu dvostukog tereta prehrane u zemljama u razvoju. Dvostruki teret prehrane definira se kao koegzistencija pothranjeosti i pretilosti u istoj populaciji/grupi, istom kućanstvu/obitelji, ili istoj osobi. Cilj ovog rada je: a) opisati različite tipove dvostrukog tereta, b) identificirati antropometrijske indikatore koji se općenito koriste za određivanje dvostrukog tereta, c) usredotočiti pažnju na grupe s dvostrukim teretom (grupa Maya iz Meride, Yucatan, Mexico), d) ukazati na problem u kategorizaciji dvostrukog tereta, i e) sugerirati moguće zdravstvene implikacije. Naši rezultati pokazuju da, na našem uzorku, prevalencija individualnog dvostrukog tereta među djecom je vrlo niska, ali je vrlo visoka među majkama i između para majka-dijete (dvostruki teret kućanstva). Ono što je najvažnije, korišteni kriteriji za određivanje hranidbenog statusa pojedinca i obitelji, će igrati važnu ulogu u prevalenciji prehrane dvostrukog tereta, što će imati praktičnog utjecaja na zdravstveni intervencijski program.