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Dynamics of the Double Burden of Malnutrition and the Changing Nutrition Reality

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Abstract

The double burden of malnutrition (DBM), defined as the simultaneous manifestation of both undernutrition and overweight/obesity, affects most low- and middle-income countries (LMICs). This paper describes the dynamics of DBM in LMICs and how it differs by socioeconomic level. The paper shows that DBM has increased in the poorest LMICs, mainly due to overweight/obesity increases. Indonesia is the largest country experiencing severe levels of the DBM, but many other Asian and sub-Saharan African countries also face this problem. We also discuss that overweight increases are mainly due to rapid changes in the food system, particularly the availability of cheap ultra-processed food and beverages in LMICs while there are major reductions in physical activity at work, transportation, home and even leisure related to introductions of activity-saving technologies. Understanding that the lowest income LMICs face severe levels of DBM and that the major direct cause is rapid increases in overweight allows identifying selected critical drivers and possible options for addressing DBM at all levels.

INTRODUCTION

The global health community has been slow to acknowledge the challenge of the large proportion of low- and middle-income countries (LMICs) facing the double burden of malnutrition (DBM) – the coexistence of undernutrition (i.e., micronutrient deficiencies, underweight and childhood stunting and wasting) and overweight/obesity and diet-related non communicable diseases. Current estimates are that 2.28 billion[1] or more children and adults are overweight and more than 150 million children are stunted.[2,3]

There are a number of studies that describe double burden of nutritional deficiencies (childhood stunting/wasting and micronutrient deficiencies) and overweight/obesity affecting countries, households, and individuals. This includes the very first set of studies,[4–6]

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but is represented by a growing literature that has focused on understanding the dimensions of the problem and the causes, consequences, and possible solutions.[7–13] The analysis has pinpointed several reasons for this health crisis, many related to the stage of the nutrition transition dominated by reduced physical activity and increased access to less healthful, highly processed foods and beverages[14–21]. However, there is a gap on how to translate this evidence into effective actions.

Building on the 2013 Lancet Series on Maternal and Child Nutrition and complementing other major scientific initiatives such as The EAT-Lancet Commission on Food, Planet, Health and the Lancet Commission on The Global Syndemic of Obesity, Undernutrition, and Climate Change,[22–24] this series highlights the new nutrition reality: that there are multiple forms of malnutrition that overlap in different ways and in different places[13] and that addressing malnutrition in all its forms will require new ways of designing, targeting, and implementing programs and policies to accelerate progress in improving nutrition globally. We also want to acknowledge that the impact of undernutrition over the past 4–5 decades will impact our health for many future years. While stunting has declined greatly from the early 1990's, we must understand that the stunting of last 3–4 decades will subsequently have a great effect on subsequent increases decades later in the way of increased visceral fat and greater risks of major NCDs.[25] as discussed in the Wells et al paper and the key cohorts studies.[25–29]

This 2019 series is timely, with the recent UN Decade of Action on Nutrition and the Sustainable Development Goals shifting focus from predominantly undernutrition, or single 'sides' of malnutrition, to all forms of malnutrition.[30,31] Further, major UN and other international institutions and donors are revisiting their strategies to reconsider the scope of nutrition priorities, developing strategy documents and formulating initiatives to focus on overweight/obesity as well as undernutrition.[32]

The papers in this series take this a step further and focus on not only the epidemiology and larger societal changes in the food system and other major demographic and economic dimensions but also the biological underpinnings of stunting and subsequent adiposity and NCD risk[33]They also take this issue into the program and policy area[34] by building on the work on double duty inventions[11] which focus on reducing both undernutrition and overweight/obesity but also how ignoring obesity in programs focused on malnutrition prevention at various ages has affected obesity and the DBM[34] and focus on the economic impacts of health programs and policies.[35]

This first paper in the series introduces the epidemiology of the DBM, presents changes in global estimates of the DBM and its components and uses repeated household surveys to explore aspects of the DBM. It then provides an overview of the nutrition and food system transitions that explain the large increase in the DBM, particularly among the lowest-income LMICs. The final section discusses the[4–6]consequences of the problem and possible solutions.[7,8,12,36–38,34,39,14,40–43,14,16,44–48,39,34,38,35]

PART 1: THE DOUBLE BURDEN AND ITS PREVALENCE: COUNTRY AND HOUSEHOLD EPIDEMIOLOGY

In this and the subsequent papers of this series we use *malnutrition* to refer to both wasting/stunting/thinness and overweight/obesity. Although micronutrient malnutrition is recognized as a component of undernutrition, we have not been able to include it in our DBM estimates, due to the lack of sufficient data.[49,50,51,52–58,51,50]

Country-level double burden

DBM at the country level was defined as having a high prevalence of both undernutrition and overweight/obesity in at least one population group. We examined which countries had DBM [DBM; prevalence wasting >15% or stunting > 30% or women's thinness (prevalence >20%)]and adult or child overweight(prevalence >20, 30, 40%). The cutoffs for undernutrition ares defined as wasting (WHZ<−2) or stunting (HAZ<−2) for children age 0–4 and thinness (BMI<18.5) for adult women. For overweight (BMI Z >+2 in children under age 18 and BMI>25 for adults[36] exceeds 20%, 30%, or 40% prevalence (Figure 1 and Supplemental Tables S1 and S2). We use a combination of overweight and obesity because extensive epidemiological research associates BMI of 25 or even lower to the risks of noncommunicable diseases (NCDs) across LMICs.[37–43]

Among 123 countries with 1990s data, the number with DBM based on 20, 30, and 40% overweight prevalence was 45, 22, and 15, respectively (Figure 1a, Supplemental Table S1). Of the 126 countries with data from the 2010s, 48, 35, or 10 countries face DBM with overweight prevalence exceeding 20%, 30%, or 40%, respectively (Figure 1b and Supplemental Table S2). DBM is especially concentrated in Sub-Saharan Africa, South Asia, and East Asia and Pacific. In countries with data for both time periods, increases and decreases were roughly balanced, using the 30% and 40% cutoffs. Increases in DBM were observed particularly in Asia, whereas improvements were observed in Latin America/Caribbean and Middle East/North Africa.

Economic Development and DBM at the National Level—Examining the changes in DBM status by quartile of GDP/capita in 1990, we can see that increases in DBM from the 1990s to 2010s are concentrated in the lowest quartile countries, whereas the number of countries with DBM has declined in the top three income quartiles (Figure 2). The largest increases in number of DBM countries were observed using the 20% and 30% adult overweight prevalence cutoffs. This highlights the driving role of overweight in shaping countries now facing a high DBM, with the greatest effect among the lowest quartile of GDP/capita countries. Figure 3 further highlights these changes in DBM by income quartile. At the same time, the total number of countries with severe levels of DBM declined using the 40% overweight cutoff, related mainly to significant declines in wasting and stunting.

Household-level double burden

DBM at the household level was defined as one or more individuals with wasting/stunting/thinness and one or more individuals with overweight/obesity within the same household. It can occur in one of four ways: 1) a child is both stunted and overweight; 2) the mother is

overweight and one of her children under 5 is wasted; 3) the mother is overweight and one of her children under age five is stunted; or 4) the mother is thin and one of her children is overweight. Supplemental Table S4 shows the prevalence of each of these scenarios as well as the total prevalence of household DBM. Household-level DBM is driven primarily by the combination of women with overweight and children with stunting (highest prevalence of all four possible combinations in every country with the highest growth rate where increases are occurring). In contrast, the contribution of the fourth category of DBM (mother with thinness and child with overweight) is extremely small (less than 1% prevalence in most countries).

The prevalence of total household-level DBM ranges from <3 percent to nearly 35 percent, with over a quarter of households experiencing DBM in Azerbaijan, Guatemala, Egypt, Comoros, and Sao Tome and Principe. The total household-level DBM is shown in Supplemental Figure S1a for countries with at least two surveys more than 15 years apart. Comparing the earliest and latest surveys in these countries, five countries showed declining levels of DBM and 15 (including India, China, and Indonesia) showed increases (Supplemental Figure S1a and S1b).

Economic Development and DBM at the Household Level—In Supplemental Table S3–4, we see that the general shape of the GDP/capita and household level DBM relationship is similar in the two time periods examined (1990s and 2010s), with the highest levels of household DBM seen in the middle of the income range (Figure 4). However, the entire curve has shifted slightly upward (about 2–3 additional percentage points) in the most recent time period at all income levels.

Individual-level double burden

The Wells et al. paper addresses the underlying developmental origins biology that can lead to a child who has both stunting and overweight[44]. The prevalence of individual-level DBM for children ages 0–4 years is shown in Supplemental Table S4 and Supplemental Figure S1c. The percent of children who have both stunting and overweight ranges from <1% in Myanmar, Colombia, and Nepal to >15% in Albania. Among the 20 countries with earliest-to-latest-year data spanning 15 or more years, about half showed a decline in individual child DBM and half showed an increase (Supplemental Figure S1d).

Changes in malnutrition over time: equity considerations

Nearly all countries saw declines in child wasting or stunting, with a third of them declining by more than one percentage point per year (Supplemental Table S5). On the other hand, nearly all countries saw an increase in overweight among women, with over a third of countries increasing by more than one percentage point per year (Supplemental Table S6).

From a public health perspective, it is important to know where this overweight is emerging and whether the burden is now, or in the future, greater among the poor. To provide some sensitivity to where increased overweight is occurring, we looked at the prevalence and annualized changes in prevalence in all countries with two years of anthropometric data and we examined the differences in the changes in overweight/obesity prevalence between the

poorest and the highest-wealth quintiles in the earliest and most recent survey periods (Figure 5). A positive annualized difference indicates that the poor face greater overweight/obesity prevalence and suggests increasing disparities between the lowest and the highest wealth quintiles. (See Supplemental Table S7 for the data and Appendix 1 for the methodology.) We show growing rates of overweight/obesity among the poor in most countries in LAC, EECA, and East Asia (led by China and Indonesia). In contrast, sub-Saharan Africa and South Asia have the largest increases in overweight/obesity prevalence among higher-wealth households (Supplemental Table S7). We cannot predict with extant data if these regions will see a shift toward greater overweight among the poor in the future. A recent study shows that in all low and middle income countries other than South Asia and sub-Saharan Africa, rural overweight and obesity is growing faster than in urban areas and also highlights the need for shared solutions targeted to both urban and rural areas.[45]

The next section explores the global food systems linked with a new nutrition reality now affecting even the poorest LMICs.

PART 2: TRANSITIONS THAT EXPLAIN THE CURRENT SHIFTS IN THE DOUBLE BURDEN TOWARD THE LOWER INCOME COUNTRIES

We found that all the new DBM countries (14) were among the lowest quartile GDP/capita (PPP). At the same time, the number of countries in the upper income quartiles with DBM decreased. This reflects increasing overweight among lower-income countries that have not reduced stunting or wasting or thinness below the WHO-UNICEF cutoff levels. We focus the following discussion on the changing food system and new nutrition reality that these poorest LMICs are facing.

Economic change certainly has been critical to both the reductions in wasting/stunting/thinness as well as declines in physical activity and major shifts in the food system that have resulted in an increase in ultra-processed foods consumption.[16,20,21,46–51] In longitudinal studies in China, the increases in overweight were fueled by massive reduction in physical activity and most likely also in energy expenditure derived from the introduction of modern technology in market economic work, home production (e.g., rice cookers, refrigerators, stoves) and transportation systems.[18–21,50,52] However, it is in the diets and the food systems of most LMICs where most of the recent change in energy imbalance that causes weight gain is focused. It is very difficult for example, to offset the effects of any ultra-processed food, e.g., a 355 ml bottle of sugar-sweetened beverage, as the consumer would be required to undertake a 1.5 mile walk or run for at least 15 minutes.[5,48, 57, 61, 62] Thus, we discuss below mainly the shifts in the food system and diet changes overtime.
15,48,66–68,40,41,43,60–6318–21,64,65,53

We conceptualize the food system as the entire process from production to the consumer.[54–56] This system includes the activities, infrastructure, and people involved in feeding the global population. Over the past several decades we have seen not only greater relative influence and power among the various actors who affect and direct production but also the penetration of modern food retailing and marketing throughout most LMICs. Here we touch on these dramatic changes only briefly. A more in-depth discussion of these changes can be

found elsewhere[16] and in more detail for LAC.[56] These food system changes are clearly important for weight gain and overweight status but the literature on how these changes affect undernutrition is less clear and very understudied.

The general concept of the nutrition transition is that in each region of the world (not only countries but subregions within countries), a transformation in the way people eat, drink, and move at work, at home, in transport, and in leisure has affected the distribution of body composition and created nutritional problems.[57,58] The transition has produced remarkable shifts in physical activity and diets in LMICs and a rapid increase in overweight, obesity, and nutritionrelated NCDs.[20,21,50,52] As noted above, we only have suggestive information on ways this transition affects infant diets for those facing a high risk of stunting and wasting.[47,49,51,59] We have no studies in recent years on the exact causes of country-level or even household-level DBM. But we will describe briefly a new nutrition reality that is rapidly becoming the major driver of overweight and obesity among lower income countries and also has unclear but increasing effects on undernutrition.

The new nutrition reality

The new nutrition reality is particularly important to acknowledge, because diet is an important driver of DBM.[60,61] While we understand that changes in the last several decades in food marketing, access, and purchase of packaged processed foods have demarcated a new nutrition reality across the globe, this paper focuses on the impact on all LMICs while attempting to understand the effects on countries in different regions and with varying income levels.[62–64] The growth in retail food[62,65,66] and the control of the entire food chain in many countries by agribusinesses, food retailers, food manufacturers, and food service companies have changed markedly.[56,67] This has been accompanied the increased consumption of ultra-processed food purchases in LMICs.[68,69] Ultra-processed, packaged foods rich in refined carbohydrates, fat, sugar, and salt are relatively inexpensive and often ready to eat.[70]. Recent evidence suggests these ultra-processed foods play a major role in increased obesity and NCD's. A randomized controlled trial conducted by a team at the U.S. National Institutes of Health showed that normalweight adults lost 0.9 kilograms in two weeks when fed a real food diet and gained 2.1 kilograms when fed a diet composed of ultra-processed foods, following a cross-over design.[14] It is unclear from this study if it is the hyperpalatability of ultra-processed food or the much higher energy density of such foods. Additionally, two large European cohorts have recently shown a strong positive relation between ultra-processed foods and cardiovascular disease and all-cause mortality (Lawrence and Baker 2019; Rico-Campà et al. 2019; Srour et al. 2019). The role of ultra-processed foods on stunting remains less clear. though we would expect they are replacing nutrient-rich, energy dense foods.[14,71,72] Intake of ultra-processed foods during the first thousand days is increasing and represent a newly emerging likely contributor of stunting, [46–49,51,53,59,73] therefore perpetuating the DBM.

The retail revolution

The retail revolution, where fresh markets have increasingly disappeared, and large and small food retailers have replaced them, has swept the globe, as a series of studies by T. Reardon and others shows.[62,63,65–67,74] In LAC, packaged processed food sales increased

from about 10% of all food expenditures (both in cash and in-kind sales) in 1990 to 60% in 2000. The bulk of this increase appears to be in ultra-processed unhealthy foods and beverages. That growth continues in the Latin American and Caribbean region. with large increases in ultra-processed categories of foods and beverages[56,65,75] Similar increases in the penetration of modern food retailer emerged at different rates across Asia, Africa, and the Middle East.[66] The Persian Gulf states[66] have not been studied as carefully, though we presume they experienced similar growth even earlier as the area urbanized and experienced rapid growth in incomes. The changes vary across sub-Saharan Africa, North Africa, East, Southeast, and South Asian countries but change is accelerating in most countries.[62,63,76]. which in urban areas was already dominated by a modern food retail sector in the mid-1990s, most growth in the African market has occurred in the twenty-first century.[64]

Controlling the food supply

The actors who control the food supply are changing. At the time of the green revolution and the development of the global agricultural research sector, countries, large agribusiness firms in the seed and fertilizer area and global foundations generated the change.[54,56,67,74,75,77] While they still play major roles in producing new technology, control of the food chain is transforming. Case studies from China, Bangladesh, and India were the first to remark on this[67] and later research showed similar trends in Africa.[63] These studies showed that the global and national public sectors were no longer the major influences in LMIC diets. Rather, food retailers, food agribusinesses, global food companies, and the food service sector and their domestic cloned counterparts directly impacted farmers.

Nonessential foods and beverages

Sales of nonessential foods and beverages are growing rapidly. Sales volume data from Euromonitor International demonstrates trends in increasing sales of nonessential or junk foods and SSBs in Chile, South Africa, the Philippines, and Malaysia (Supplemental Figure S2).[78] Supplemental Tables S8 and S9 present the sales data from Euromonitor International used to model the GDP relationship with both sales volumes and annualized changes in sales of SSBs (Supplemental Figure S3) and junk foods (Supplemental Figure S4) in LMICs using data regressions.[78] These results show how large SSB sales already were in lower-income countries by 2017. The rapid growth of junk foods and SSBs in these countries exemplifies how aggressive this food sector is. India and China are two of the top five markets for sugary beverage manufacturers (Supplemental Figures S5 and S6) and are expected to become their major markets in the next decade. The speed of change is particularly important in understanding how this nutrition reality is shifting.

Key drivers of the new nutrition reality

In LMICs urbanization, migration to cities, income growth, infrastructure improvements, and global trade policy liberalization have spurred private investment in the food sector. [56,63,74,77] The roles of income growth[79] and other drivers associated with diet changes should not be downplayed. Equally important, women working outside the home[56,80] and their opportunity costs of time have shaped the demand for food that is ready to eat or ready to heat.[81] C.A. Monteiro calls this convenience in food preparation and consumption the ultra-processed food revolution.[68,69] Modern marketing and access to mass media have

added to changes in conceptions of the ideal set of foods. But while power is shifting to large-scale food retailers, manufacturers, and food service companies,[56,67] the informal sector and smaller local companies remain understudied components of the food sector who are often important sources of food for low-income and rural populations.

CONCLUSION

This paper has shown that LMICs countries continue to experience high levels of DBM; however, those countries with the current higher levels of DBM are lower income levels than in the early 1990s. The analysis of the dynamics of undernutrition and obesity suggest that it is the rapid increases in prevalence of overweight/obesity occurring in these lower income countries which are also experiencing a slower decline in the prevalence of undernutrition. A greater number of new countries with high levels of DBM were in the lowest GNP/capita (PPP) quartile of LMICs than in the 1990's. We show that this new nutrition reality is driven by important and rapid changes that have taken place in the food system. Conversion of the global and domestic retail food, food service, and agribusiness sectors of the economy, along with other transformations,[55,56,63,67] have resulted in an important increased availability of ultra-processed foods in LMICs. Ultra-processed food consumption has been linked to overweight/obesity and NCDs risk and there is preliminary evidence that its consumption during the first 1,000 period (pregnancy and infancy) early-life window could be also linked to stunting. There is an urgent need for understanding and tackling the drivers of the food system shift and enacting effective policies that address the challenges of the DBM.[48,67,71,78]

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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Acronyms

GDP/cap (PPP)	gross domestic product per capita based on purchasing power parity
PPP	purchasing power parity
LAC	Latin America and the Caribbean
MENA	Middle East and North Africa

EECA	Eastern Europe and Central Asia
LMICs	low- and middle-income countries
SSBs	sugar-sweetened beverages
DBM	double burden of malnutrition
SES	socioeconomic status
NCDs	noncommunicable diseases
WHO	World Health Organization
UNICEF	United Nations Children's Fund
NCD-RisC	Non-communicable Disease Risk Factor Collaboration (generated the data found on the Institute of Health Metrics and Evaluation website)
DHS	Demographic and Health Surveys

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Key messages:

- In low- and middle-income countries (LMICs), stunting, wasting and thinness in women are declining while overweight increases in most age groups. A total of 48, 35, or 10 countries presented severe levels of double burden of malnutrition (DBM; wasting >15% or stunting > 30%, women's thinness (and women's thinness(BMI< 18.5 >20%)and adult or child overweight(>20, 30, 40%) according to most recent survey years.
- Severe levels of the DBM shifted to the countries in the poorest income quartile. Whereas several decades ago, the double burden was typically seen more in the higher-income LMICs, today it predominates in countries with much lower gross domestic products per capita, particularly in South and East Asia and sub-Saharan Africa.
- Increases in overweight are the results of changes in the global food system that make less nutritious food cheaper and more accessible while physical activity is decreasing due to major technological shifts in market, home production and transportation. In South Asia and Sub-Saharan Africa countries, the risk of overweight/obesity is greater among the higher wealth households and urban areas while in many other LMICs the risk is starting to concentrate among low-income people and rural areas.
- LMICs face a new nutrition reality. The shifts in the global food system are accelerating increases in overweight. Concurrently these same shifts have changed the diet of infants and pre-schoolers but the impact on stunting needs further research. LMICs need to implement interventions to improve diet quality in order to address under- and overnutrition across the lifecycle.

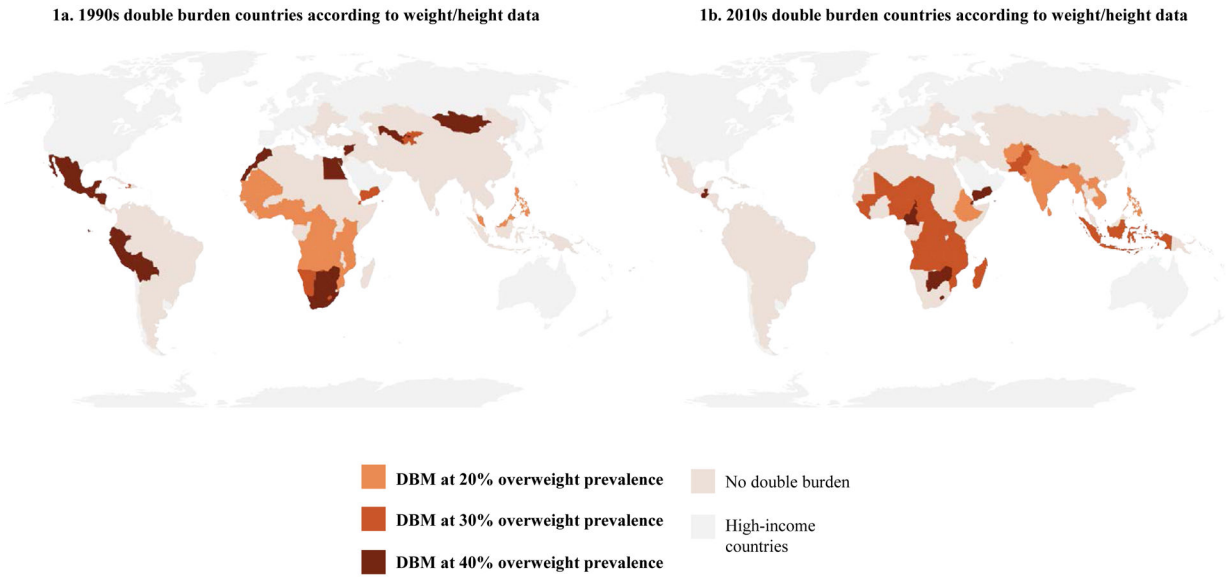

Figure 1. The global double burden of malnutrition in low- and middle-income countries based on 1990s and 2010s weight and height data*

(using UNICEF, WHO, World Bank, and NCD-RisC estimates, supplemented with selected DHS and other country direct measures)

* Double burden of malnutrition (DBM) = at least 1 child, adolescent, or adult in household with severe levels of wasting/stunting/thinness and 1 with overweight/obesity (shown at 20%, 30%, or 40% overweight prevalence)

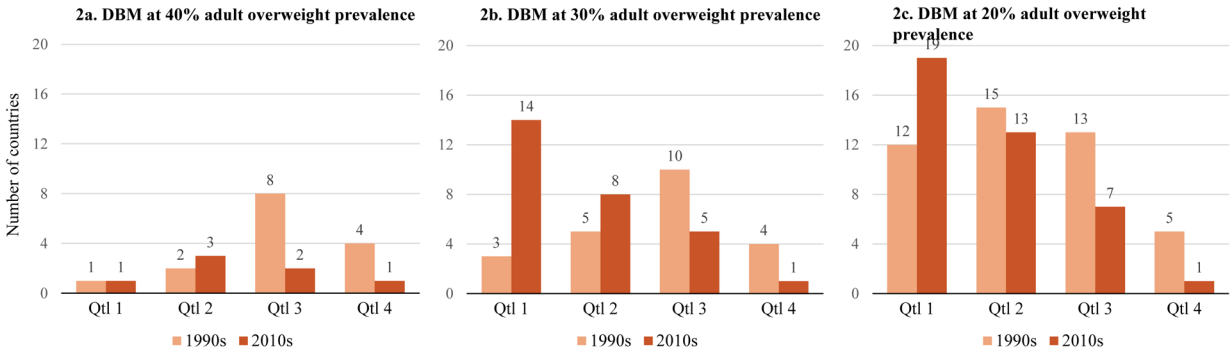

Figure 2. Countries with high double burden of malnutrition* in 1990s and 2010s, by time period and GDP/capita (PPP) quartile**

* Double burden of malnutrition (DBM) = at least 1 child, adolescent, or adult in household with severe levels of wasting/stunting/thinness and 1 with overweight/obesity(shown at 20%, 30%, or 40% adult overweight prevalence); countries only included here if they had DBM data available for bothtime periods (1990s and 2010s)

** Quartile (Qtl) 1 is lowest-wealth, Qtl4 is highest-wealth

Data sources: Based on UNICEF, WHO, World Bank, and NCD-RisCestimates supplemented with selected DHS and other country direct measures for the 1990's

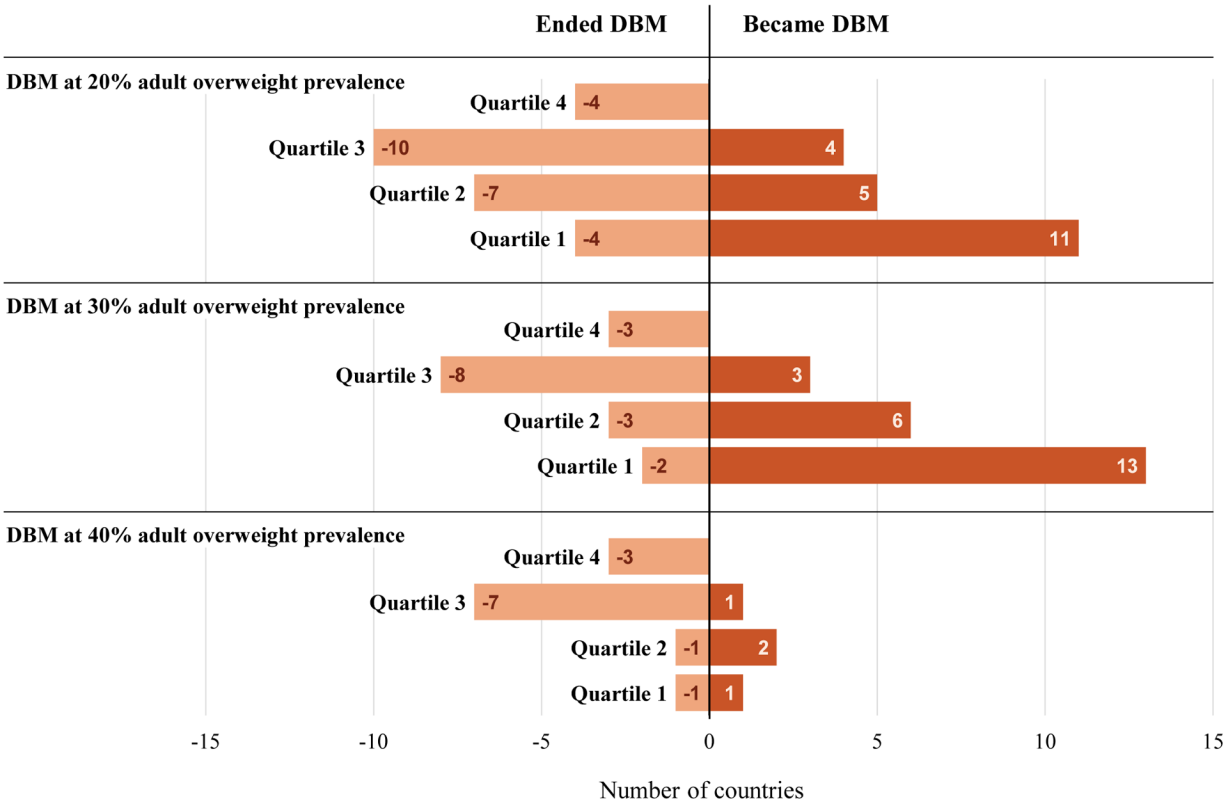

Figure 3. Number of countries that changed double burden of malnutrition* status from 1990s to 2010s, by GDP/capita (PPP) quartile

* Double burden of malnutrition (DBM) = at least 1 child, adolescent, or adult in household with severe levels of wasting/stunting/thinness and 1 with overweight/obesity(shown at 20%, 30%, or 40% adult overweight prevalence); countries only included here if they had DBM data available for bothtime periods (1990s and 2010s)

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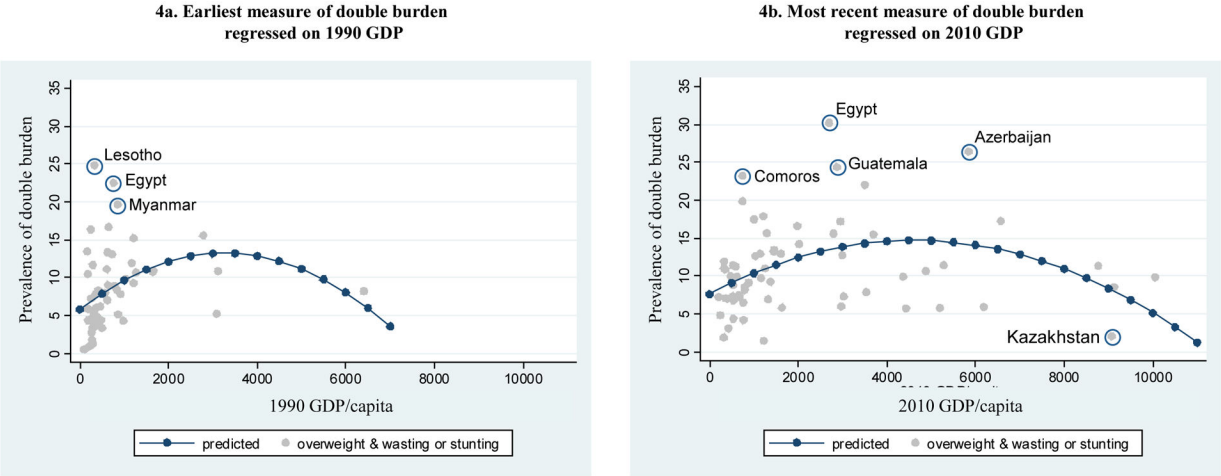

Figure 4. The association between GDP-PPP and regressions relating GDP per capita to household double burden

Sources: The data are from the Demographic and Health Surveys (DHS, https://dhsprogram.com/), with the exceptions of China (China Health and Nutrition Survey), Indonesia (Indonesian Family Life Survey), Mexico (Mexico National Survey of Health and Nutrition), Brazil (Brazil National Health Survey), and Vietnam (Vietnam Living Standards Survey).

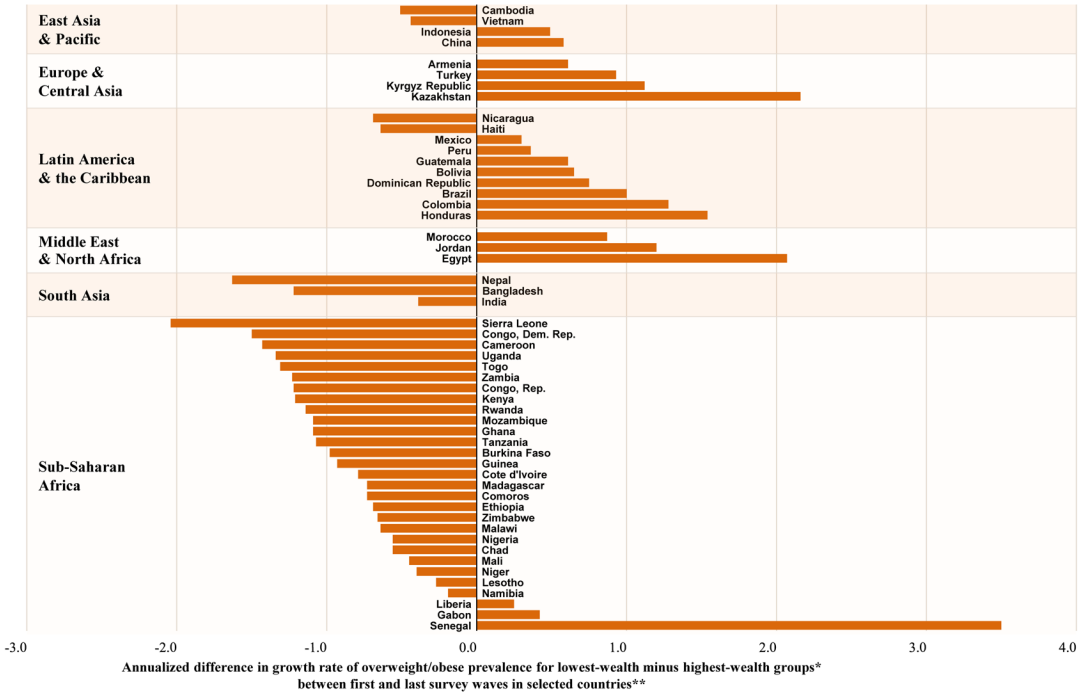

Figure 5. The shifting burden of overweight/obesity from higher- to lower-wealth populations in sample countries**

* Positive difference indicates higher annualized growth in overweight/obesity prevalence for the lowest-wealth quartile.

** Countries presented here had earliest-to-latest-year data spanning 15 or more years, latest-year data after 2010, and a population greater than ≈15 million (with the exception of Jordan andKyrgyz Republic, which both had smaller populations but were included for regional representation). The data presented is from years spanning 1988 to 2016, but exact years vary by country.The span of earliest-to-latest years collected ranges from 15 years to 24 years. All data are from the Demographic and Health Surveys (DHS, https://dhsprogram.com/) with the exceptions ofChina (China Health and Nutrition Survey), Indonesia (Indonesian Family Life Survey), Mexico (Mexico National Survey of Health and Nutrition), Brazil (Brazil National Health Survey), andVietnam (Vietnam Living Standards Survey).