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Economic effects of the double burden of malnutrition

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Observations from many countries indicate that multiple forms of malnutrition might coexist in a country, a household, and an individual. In this Series, the double burden of malnutrition (DBM) encompasses undernutrition in the form of stunting, and overweight and obesity. Health effects of the DBM include those associated with both undernutrition, such as impaired childhood development and greater susceptibility to infectious diseases, and overweight, especially in terms of increased risk of added visceral fat and increased risk of non-communicable diseases. These health effects have not been translated into economic costs for individuals and economies in the form of lost wages and productivity, as well as higher medical expenses. We summarise the existing approaches to modelling the economic effects of malnutrition and point out the weaknesses of these approaches for measuring economic losses from the DBM. Where population needs suggest that nutrition interventions take into account the DBM, economic evaluation can guide the choice of so-called double-duty interventions as an alternative to separate programming for stunting and overweight. We address the evidence gap with an economic analysis of the costs and benefits of an illustrative double-duty intervention that addresses both stunting and overweight in children aged 4 years and older by providing school meals with improved quality of diet. We assess the plausibility of our method and discuss how improved data and models can generate better estimates. Double-duty interventions could save money and be more efficient than single-duty interventions.

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Introduction

The double burden of malnutrition (DBM) in low-income and middle-income countries was recognised by economists as important by 2001, but has not been extensively studied. The DBM is now receiving greater attention as it appears to be more permanent and widespread than earlier perceived, which implies greater economic effects.[1] More than two decades ago, Popkin and colleagues[2] identified costs of 1% and 2% of gross domestic product (GDP) from undernutrition, overweight, and associated non-communicable diseases in China and India, respectively. Popkin projected that the cost could reach 9% of GDP in China by 2025.[2] The World Bank estimated economic costs of 2–3% of GDP in Indonesia in 2012.[3] Yet major challenges remain in assessing the economic effects of the DBM, and the return on investments in reducing it.

In this Series paper, we examine methods for doing economic evaluations of the DBM, identify gaps, and recommend improvements to economic modelling while additional empirical data are awaited, and provide an example of how to evaluate the costs and benefits of an intervention designed to address the DBM in three developing countries. The cost–benefit analysis is intended purely as an illustration of what can be learned by doing economic evaluations of actual double-duty interventions, which is not yet feasible with available evidence. Our primary goal is to consider the challenges to economic modellers of estimating the effects of the DBM. Our secondary goal is to draw attention to the need for better programmatic evidence for so-called double-duty interventions that can address the DBM.

Measuring the economic costs of malnutrition

Reasons for the few studies on the economic effects of the DBM include challenges in harmonising different long-term outcomes for chronic undernutrition and obesity, diffuse and not easily measured health and economic effects of poor nutrition, scarcity of data on all forms of malnutrition within the same population, and limited economic modelling for nutrition. A subtle but important consequence of this point is that the DBM falls between distinct and largely separate undernutrition and obesity advocacy and expert communities and is not the priority of either community. Therefore, differences exist in the methods used by nutrition economists to measure economic effects of multiple forms of malnutrition.

Key messages

- Existing economic models for nutrition are not designed to measure the effects of the double burden of malnutrition
- Adding up the separate economic effects of undernutrition, and overweight and obesity is a second-best approach to measuring economic effects of the double burden of malnutrition
- Economic models need to be enhanced to incorporate effects for both undernutrition and overweight in the same population
- Using a double-duty intervention to reduce the double burden of malnutrition might be economically advantageous compared with addressing malnutrition with separate interventions for undernutrition and overweight, but of intervention evidence is insufficient and limitations of economic models prevent a firm conclusion

Those studying the effects of undernutrition generally use structural models and microlevel longitudinal data to examine the cognitive and productivity effects of early-life nutritional deficiencies.[4,5] The economic effect of overweight and obesity is generally measured with a cost-of-illness approach that measures direct medical exiture for obesity treatment, or for treatment of obesity-related diseases such as cardiovascular disease and diabetes. Few studies focus on reduced productivity and earlier retirement related to overweight in low-income and middle-income countries.[6,7] Thus economists have resorted to measuring the economic burden of each form of malnutrition separately and added the individual burdens to find a combined burden. However, this method does not account for possible interactions that could either diminish or exacerbate the combined effects, compared to effects when only one form of malnutrition is present. This possible interaction is a challenge for measuring the effects of double-duty interventions for the DBM, which we note but do not resolve in our analysis.

We did a scoping review of the best-known models that provide economic outcomes of nutritional status, for both undernutrition and overweight. We assessed the key characteristics of those models for purposes of analysing the economic effects of the DBM. Although the review was not exhaustive, it was comprehensive enough to highlight the main features of and differences in models that impede economic analysis of the DBM. Appendix 1 provides selected results of that review emphasising obesity models because they are more diverse than economic models of undernutrition.

See Online for appendix 1

Models that measure the economic effects of undernutrition

Models of the economic effect of stunting take the number of children who are stunted in a given population as a starting point, and then estimate the effect of undernutrition on economic productivity and mortality via changes in linear growth. Some models also take into consideration the economic costs of chronic undernutrition on cognitive development, schooling, and earnings. Results are typically presented as either share of GDP lost to stunting or as benefit–cost ratios for investments to reduce stunting.

The Lives Saved Tool (LiST) is an epidemiological model that analyses the effect of health and nutrition interventions on maternal, newborn, and child health.[8,9] To measure the economic effect of interventions, the model draws from well-designed cohort and experimental studies with both direct measurement of the long-term economic effects of poor childhood nutrition and proxies for poor nutritional status, usually height or growth faltering, which are then linked to educational attainment or wages to measure aggregate economic effect.[4,10,11] The second paper of this Series[12] highlights the biological long-term outcomes of early malnutrition, but these are rarely linked to long-term economic outcomes.

Other econometric approaches look at stunting as a function of individual, household, and environmental factors, but these economic analyses are not amenable to integrating with the existing set of obesity micro-simulation models. These models focus only on children younger than 5 years and do not include undernutrition in other key demographic groups (adolescent girls, pregnant and lactating mothers) or associated with other risks, such as micronutrient malnutrition.

The economic effects of stunting include cognitive and other developmental deficits that affect lifetime productivity, greater incidence of infectious and parasitic disease that cause physical impairments, and greater risk of chronic diseases in adults, with their attendant high medical and indirect costs.[4,5,13–16] Horton and Steckel[17] provide a global estimate of the economic costs of chronic undernutrition using deficits in mean height due to stunting. They find GDP losses of up to 12% in some low-income and middle-income countries, and totalling 8% of global GDP during the 20th century. This study projects lower GDP losses between 2000 and 2050 because of improvements in nutrition in Latin America and Asia. Hoddinott[18] summarises the costs of malnutrition from a study of seven African countries and finds losses of 3–16% of GDP, with an average loss of 7·7% of GDP. Other country-level estimates of economic effect show decreases in earnings and household consumption from childhood stunting (1·4% lower wages in Mexico, 10% lower earnings in low-income countries, and 66% lower household consumption in Guatemala).[4,19,20]

Models that measure the economic effects of obesity

In contrast to economic measures of undernutrition, empirical studies of economic burden of overweight generally look at the cost-of-illness from obesity and related non-communicable diseases, direct medical costs and indirect costs, or productivity losses, associated with early mortality and morbidity. Sometimes other indirect costs are included, such as transportation costs from seeking treatment and human capital costs due to lower investment in education and training.[21] Caution is needed in interpreting these estimates because the economic burden from overweight is only a fraction of the cost attributable to overweight-related non-communicable diseases. The indirect costs or productivity losses from absenteeism, disability, presenteeism (working while sick), and worker's compensation in the USA and other high-income settings typically account for 70% of the total global cost of obesity.[22,23] Economic microsimulation and macrosimulation models are used to evaluate the effect of an intervention or policy on health outcomes, disability, or premature death associated with hypertension, diabetes, cancer, stroke, and other obesity-related disease.[6,24–31] The models typically simulate food intake in a given population and look at the effect of changes in policies or interventions on food security, body-mass index (BMI), diabetes risk,

and mortality from cardiovascular disease. Key to most of these models is their ability to model changes in food intake on the basis of available estimates of price and income elasticities of demand. Not all models have the same features; however, they all model distal, intermediate, and proximal risk factors on disease outcomes, disability, and death. The models require substantial demographic, epidemiological, disease burden, and economic data. We describe the characteristics of some example models next.

The UK Foresight obesity model, applied in Brazil, Mexico, and other country settings, is a dynamic computer microsimulation model applied to different populations.[6,7,32] The model tracks individuals through their lifecycle and applies a probability of being overweight, obese, or normal BMI. The model runs over an extended period and makes predictions of individuals having a risk of getting a particular disease, surviving, or dying, based on their BMI. The model is able to simulate the effect of interventions to prevent disease or death and compare the effect and costs of hypothetical interventions. Similar obesity models have been developed and mostly applied in high-income and middle-income settings.

Basu and colleagues[27] developed a metabolic-epidemiological microsimulation model to assess what population level changes in calorie intake and physical activity would be required to meet US federal guidelines to reduce the prevalence of obesity. Other obesity models use economic-epidemiological approaches to assess the effects of health-related food taxes or subsidies on health outcomes related to dietary risk factors. Most of these models have been developed to assess fiscal policy options, such as taxes on saturated fat, salt, sugar, and sugar-sweetened beverages, or subsidies on fruits and vegetables.[28,29,33]

The Organisation for Economic Co-operation and Development (OECD) and WHO developed the most comprehensive microsimulation model to date that includes the causal chain of lifestyle risk factors for cancer, stroke, and ischaemic heart disease. The model captures a range of risk factors, from more distant exposures (dietary intake and physical activity) to proximate risk factors, such as hypertension and diabetes. Cecchini and colleagues[26] applied this model to seven countries exploring the effects of school-based, workplace, population based, fiscal, and regulatory interventions on health outcomes and expenditures.[31] A broader set of countries and outcomes is modelled in more recent work.[31]

Models that measure the economic effects of the DBM

Few studies have measured the economic costs of the DBM per se. Popkin and colleagues looked at the cost of diet-related non-communicable diseases from undernutrition and overweight in China and India in 1995 and 2025.[2] Later, Popkin and colleagues[2,34] proposed a model to measure the direct effects of childhood stunting on overweight and obesity, and chronic diseases. The World Bank estimated GDP losses from the DBM in Indonesia.[3] However, the focus of those studies was on cost of non-communicable diseases, rather than the DBM itself.

An exception to the non-communicable disease focus is a model developed by the Economic and Social Commission of Latin America and Caribbean (ECLAC) and World Food Programme (WFP).[35] The modelling perspective is broad, aiming to account for multiple drivers of the DBM and to reflect the transitional and lifecycle aspects of malnutrition. For that purpose, this model introduces a multicohort life stage analysis based on each country's demography and epidemiology.

The ECLAC-WFP model separately measures effects of undernutrition and obesity in the standard ways described above. The model contemporaneously measures the economic costs of the DBM, accounting for the age structure of the countries, and then projects them over the 65 year anticipated life for the entire national populations of the countries studied. The ECLAC-WFP model measures lifetime effects of childhood undernutrition through multiple pathways; notably, increased risk of multiple diseases, lower educational attainment, and reduced lifetime earnings. Economic effects of overweight and obesity include medical costs and productivity losses. These two types of economic burden are then aggregated for total cost of the DBM.

The ECLAC-WFP model results range from a total cost of 0·2% of GDP in Chile to 4·3% of GDP in Ecuador (2014). For Chile, all of the economic burden of malnutrition derives from overweight and obesity; in Ecuador, the total economic burden is derived from a 2·6% loss of GDP due to undernutrition and a 1·7% loss of GDP due to overweight and obesity; and in Mexico, the undernutrition burden is 1·7% of GDP and the overweight and obesity burden is 0·6% of GDP (2014).

The ECLAC-WFP model, unlike other studies, adds the economics costs of undernutrition and overweight to reach a total economic cost of the DBM. There are several important advances from this analysis, first, it applies consistent assumptions to measure the economic burden of both undernutrition and overweight and obesity. Second, the lifecycle analysis that connects childhood malnutrition to adult malnutrition with projections of future economic costs based on population demographics and epidemiology captures the important transitional aspect of the DBM. The result is that overweight and obesity are shown to be bigger threats to economic wellbeing over time compared with undernutrition. The economic costs of obesity and overweight are projected to range from 0·4% (Chile) to 3·1% (Ecuador) of GDP between 2015 and 2078. Additionally, undernutrition is projected to result in only a 0·03% GDP loss in Mexico and 0·06% GDP loss in Ecuador during the same period.

A weakness of the ECLAC-WFP approach, which is clearly acknowledged, is the model's inability to capture interactions between undernutrition and obesity that

could affect economic impacts. Such interactions are not well established, and further research is needed to determine whether they are significant and in which direction they would influence economic effects. Authors of the ECLAC-WFP study recommend that cohort studies be conducted with the aim of measuring interactions between different forms of malnutrition. A recent cross-sectional study in Burkina Faso provided evidence of persistent micronutrient deficiencies (iron and vitamin A) concurrent with a high prevalence of overweight among women, suggesting that economic studies should be enhanced to consider such interactions when modelling the DBM.[36]

Improvements needed in economic modelling to assess the DBM effects

We found that most economic models of malnutrition evaluate costs and outcomes associated with either stunting or overweight and obesity, but not both, with the exception of examples noted earlier.[2,37] Additionally, the two bodies of literature (stunting, and overweight and obesity) use different methodologies and answer different economic questions. We did not review the many models that assess economic effects of micronutrient deficiencies as we are focused on models that can be adapted for the DBM.

Although Popkin and colleagues[2,34] have modelled the direct effects of childhood stunting on overweight and obesity and chronic diseases, none of the other obesity microsimulation models noted earlier has looked at cohorts of children younger than 5 years to incorporate both stunting and overweight in the same model or used microsimulation models to evaluate the effects of policies and interventions on food consumption, dietary intake, changes in weight or anthropometric measures (wasting, stunting, underweight), and effects on nutrition related illnesses and premature death. By contrast, most of the stunting models use epidemiological estimates of the number of stunted children for a given population and then estimate the effect of nutrition on economic productivity and mortality. Some models also take into consideration the economic costs of chronic undernutrition on cognitive development, schooling, and earnings. New models are needed that can evaluate the effects of policies and interventions on both undernutrition and overweight and obesity for continuous population cohorts from birth to adulthood, and for extended periods to predict effects on health and economic costs over time. There are no models that address the DBM along the full causal pathway from distal to proximate risk factors and to ultimate health and economic consequences.

See Online for appendix 2

Illustration of potential economic effects of a double-duty intervention to reduce theDBM

The third paper of this Series[38] shows the unintended negative consequences of undernutrition programmes on obesity and recommends leveraging common drivers and programme platforms to achieve improved outcomes in both undernutrition and obesity. The second paper of this Series[12] points to the beneficial effects that arise from biological connections between improving nutrition and educational attainment. The economic benefits of such leveraging have not been established. In the absence of evidence either from modelling or from actual measurement of the DBM-specific interventions, we separately estimate the effects on stunting and obesity by applying the same intervention on simulated populations in three countries. This example is purely illustrative and the results do not apply to any specific context.

Interventions that address the DBM

Many effective and cost-effective interventions exist to reduce undernutrition and a smaller number of proven interventions exist to reduce overweight.[39,40] Hawkes and colleagues in the third paper in this Series[38] advocate for policies and programmes to address malnutrition in all its forms and use the term double duty to characterise such policies and programmes. While double-duty interventions might simultaneously reduce undernutrition and overweight, these interventions might imply higher cost or lower efficacy than separate interventions that focus on either undernutrition or overweight.

We reviewed policy and programmatic interventions that show promise for reducing the DBM.[41–48] We sought examples of interventions that have been implemented in one or more developing countries to address both underweight and overweight and for which we could obtain costs of implementation. We found no generalisable examples of double-duty interventions with measured effects on the outcomes that met those criteria.

Instead we chose a school feeding intervention that has been shown to have positive effects on both stunting and obesity and drew the effect sizes and costs from different studies. An advantage of choosing a school feeding programme is that they exist in many countries and show strong potential to improve healthy eating and positive nutrition behaviour among those exposed to the programme through the school platform. Our search strategy for school feeding interventions is detailed in appendix 2 pp 1–2. Appendix 2 pp 3–6 shows the key features of the relevant studies we reviewed. We recognise, as Hawkes and colleagues[38] showed in the third paper in this Series, that many school feeding interventions focus only on undernutrition and might adversely affect overweight. This means potentially that our cost estimates might be underestimated compared to an intervention designed to affect both.

Modelling the costs and benefits of school feeding on the DBM

We modelled the economic effects of school feeding programmes on the DBM in developing countries. We selected the intervention because multiple studies show effectiveness of school feeding in providing health and

nutrition benefits; some studies provide outcome measures translatable into economic benefits; and school feeding is well-defined, widely implemented, and applicable to any setting. Given the imprecision implied in taking effect sizes from different studies to capture the effects on both stunting and obesity, we have not tried to produce a more exacting economic model or quantify statistical uncertainty around the point estimates. We conduct a cost–benefit estimate of our selected double-duty intervention to prevent the DBM, loosely adopting the Copenhagen Consensus approach that has been applied to a wide array of development challenges, including, separately, undernutrition and non-communicable diseases.[4,49–53] The method allows for a comparison of costs and benefits, usually in the form of a benefit–cost ratio.[54] For methods and data sources, see appendix 2 pp 7–13.

Undernutrition and obesity effects of the school feeding programme

We sought high-quality illustrative evidence of the effect of school feeding on undernutrition and obesity. We were unable to locate studies measuring obesity effects from school feeding in a developing country. We found only one study by Sekiyama and colleagues[55] that examined the simultaneous effect of school feeding programmes on stunted and overweight fourth grade school children (mean age, 9 years and 6 months). For purposes of the analysis, we chose a school breakfast programme in a population of 407 second to fifth grade school children (mean age, 9 years) in Jamaica for stunting outcomes and a school breakfast programme in the USA for children in grades 1–12 for child obesity outcomes. We do not claim that the results of these studies are generalisable to all settings, especially lower-income settings but the study results are useful for the illustrative exercise we conducted.

The Jamaica study is a well-designed, randomised study of a school breakfast programme that measured height change in cm among stunted children. This outcome aligns with the primary outcome of linear growth used in the economic effect literature. The children who received breakfast each day gained 0·25 cm on average during the 8 months of the intervention, or, by extrolation, up to 0·40 cm per year compared with children in the control group.[56] Standardising this effect to a school year (consisting of 200 feeding days) resulted in a 0·3125 cm gain in school age child height. For obesity effects, we used a school breakfast programme based in the USA in which children were provided daily breakfast. This study found a decrease of 0·149 in BMI for every increase in intake of one breakfast per week.[57] We standardised this effect to a school year of 200 feeding days and found a decrease of 0·827 in BMI in 1 year.

We applied both these effect sizes to the height and BMI distributions of children aged 4–5 years in three double-burden countries: Guatemala, Indonesia, and Nigeria. We chose those countries for geographical diversity and because we could obtain country-specific cost data for school feeding programmes. We had to apply the effects to cohorts of children aged 4–5 years as a proxy for their primary school counterparts aged 6–11 years because stunting information is not available for older children, who would normally be the target population for the school breakfast intervention. We acknowledge that the effects of the programme on younger children might vary from that on school children. Specifically, we might expect the effects of a good school feeding programme to be larger for older children who have greater autonomy in their dietary choices than do younger children who generally eat within the household and whose diet quality is managed by adults.

Estimation of the economic benefits of school feeding

We modelled the effects of height and weight changes from the school breakfast programme to the child populations in our chosen countries to obtain the number of cases of stunting and obesity averted as a result of the interventions. We then translate these health outcomes into economic outcomes, placing a monetary valuation on changes in health. The figure shows the analytical approach, underlying assumptions and effect sizes used in this analysis.

The economic benefits of lower stunting arise from higher human capital. Stunted children can gain years of education from improved nutrition. Following Fink and colleagues,[10] we calculate that 1 additional year of

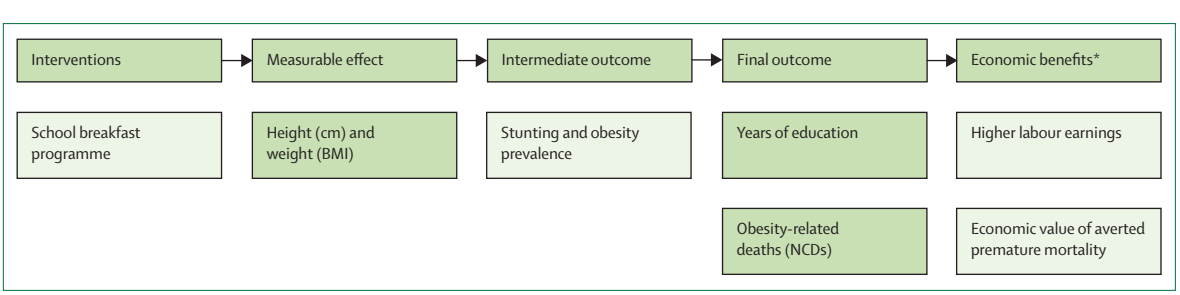

Figure: **Steps used in measuring economic effects of school feeding interventions on the DBM**
BMI=body-mass index. DBM=double burden of malnutrition. NCDs=non-communicable diseases. *Other positive outcomes result from the intervention (eg, school feeding programmes lead to higher school attendance and health-care savings from avoiding obesity).

education results in additional annual earnings (9·3% higher wages in Guatemala, 3·8% in Nigeria, and 5·8% in Indonesia).We apply the increased earning potential to individuals who avoid stunting, assuming that their average income is equivalent to two-thirds of GDP per capita.

The economic gains from lower obesity or overweight arise from lower premature mortality and from reducing disability. Using the before and after population-attributable fractions, we calculate the number of obesity-related deaths in the affected cohorts for each year after the cohort turns 20. We value each additional year of life at 1 times GDP per capita multiplied by a region-specific factor of the value of a statistical life-year, as obtained from Jamison and colleagues.[58]

Cost of school feeding programme

In 2008 US$, the estimated per-capita costs of school feeding programmes is $35·26 (Guatemala), $19·94 (Indonesia), and $55·82 (Nigeria).[59] The costs were specific to these countries and standardised to a 200 feeding-day programme. Using the school feeding population of 4–5 year olds, the per child costs provided in this study were multiplied by the population in each country to provide the final cost estimates. The programme was costed from 2018 to 2025.

Net economic benefits of school breakfast programmes (2018–90)

In Guatemala, Indonesia, and Nigeria the school breakfast programme intervention provides significant benefits that outweigh the costs of implementation. Net benefits range from 206 million to 3·1 billion US$, with the highest return on investment in Indonesia, driven in part by a high school attendance that allowed the programme to reach a high proportion of the cohort of children aged 4–5 years in Indonesia (table).

The benefits of the breakfast programme include the economic value of increased education (and future earnings) for children who avoid stunting and the economic value of averting premature mortality due to obesity related causes. Combining the benefits from reducing stunting and obesity, 54% of the benefits are derived from the economic value of increased education as a result of avoiding stunting, and 46% is derived from the economic value of averting premature mortality due to obesity. By measuring the effect on all forms of malnutrition, we find that the benefits from the intervention are doubled. Removing either form of malnutrition from the analysis would have lowered the return on investment for Guatemala and Indonesia and would have lowered it to below one in the case of Nigeria, changing the perception of whether the intervention should be carried out or not.

	Benefits (2016 US$)	Costs (2016 US$)	Return on investment
Guatemala	206 million	97 million	2·1
Nigeria	2·3 billion	2·1 billion	1·1
Indonesia	3·1 billion	753 million	4·2

Table: **Costs, benefits, and return on investment for a school breakfast programme in three countries**

Discussion

Earlier studies of the economic burden from stunting and obesity have shown substantial costs from both forms of malnutrition, but only a few estimates demonstrate the economic effects of the DBM. In the absence of models that can measure the economic effects of the DBM and of interventions designed to reduce the DBM we separately estimate the nutrition and health effects of a double-duty intervention. We then used an economic modelling approach to estimate the costs and benefits of a school breakfast programme to prevent the DBM in Guatemala, Indonesia, and Nigeria. We find that a school breakfast programme provides substantial benefits that outweigh the costs of implementation, with return on investment between 1·1 and 4·2.

This analysis has substantial limitations, including the absence of a model and data for analysing the economic effects of the DBM. Instead we applied a sophisticated microsimulation model for undernutrition (LiST) and a simple model to obtain the obesity effects of double-duty interventions. The intervention effect data were derived from separate populations. We made important assumptions about those populations, transferring the intervention benefits and costs from the literature for other settings and assuming a normal distribution of malnutrition in those populations. We applied the intervention to children aged 4 years and older in three DBM countries based on an effect size taken from children aged 4–5 years. As such, our results are merely illustrative of the economic benefits that could be achieved from addressing the DBM in those populations. We measure the effects of reduced mortality and acknowledge that our estimates exclude disability for which we lack measures in low-income and middle-income countries.

Our analysis was challenged by the insufficient evidence from actual DBM interventions from a range of low-income and middle-income countries because of (often highly) incomplete information and from differences in measuring outcomes and costs across sectors. These challenges hampered our ability to generate harmonised effects of our selected intervention.

To advance research in this field, several prerequisites are needed First, a standardised definition of the DBM is needed for each of the relevant levels of society such as individual, household, and national. While we now have improved epidemiological estimates of the DBM at different levels of the population (Popkin and colleagues,[60] the first paper in this Series), there is no global consensus as to which forms of malnutrition are

included, or what measure individually or collectively leads to the designation of the DBM. This Series focuses only on stunting and overweight and excludes micronutrient deficiencies that have been shown to have additional major economic and health costs.

Well-designed studies are needed of nutrition interventions that collect synchronous undernutrition and obesity outcomes from multiple different populations and contexts. We recommend identifying a small number of outcomes that are meaningful for multiple populations over time, such as a change in BMI, or specific nutrient intake. This approach can strengthen understanding of the emergence and persistence of the DBM in some contexts and not others.

Models that incorporate nutrition epidemiology, demographics, and economic measures should be developed to capture the costs and benefits of interventions to address the growing burden. A DBM economic model should be designed to test the proposition that a double-duty approach can achieve the same reductions in both undernutrition and overweight simultaneously at lower cost than reducing them separately.

Conclusion

This paper highlights the need to create a stronger empirical framework and suitable population-based models for guiding the economic assessment of double-duty interventions to mitigate the consequences of the DBM in low-income and middle-income countries. We demonstrate how double-duty interventions can reduce the economic effects of both forms of malnutrition. We anticipate that better definitions, combined with effect and cost data from real experience in the coming years, will input into a range of models that will provide better estimates of economic effects and the cost–benefit of employing double-duty interventions to reduce the DBM.

Existing frameworks map well the effect of nutrition-specific interventions for addressing undernutrition to a set of health outcomes related to stunting, micronutrient deficiencies, morbidity, and mortality. Similarly, frameworks exist to evaluate the effect of interventions to address overnutrition on BMI and obesity-related health outcomes, such as cardiovascular disease, stroke, and diabetes. The absence of a combined framework has hindered the development of comprehensive models to assess the economic effect of country experiences in a changing nutrition environment.[61]

We recommend the following future research to address these gaps. First, research is needed to understand the DBM, its drivers, and consequences. Second, validate a data-driven modelling tool that can project trends in the DBM (that includes both undernutrition and overweight in the same model) and related health outcomes for use by national and global policy makers. Third, identify and model cost-effective strategies to support investments to address the DBM. A starting point is to do a landscape analysis of the existing microsimulation models that are currently focused on health outcomes related to overweight and obesity, and identify models that could be modified to integrate information on underweight, stunting, and related morbidity and mortality. Finally, identify countries that are rich in epidemiological, health, agriculture, nutrition, and demographic data that can be used to populate and validate the models. These case studies should be used to introduce the framework and modelling approach to a broader set of researchers and decision makers for adoption and application in global and country settings.

Contributors

RN and CL designed the study and wrote the manuscript. BH and JH did the literature search and review. BH did economic impact calculations. All authors provided intellectual content, read, and approved the manuscript.

Declaration of interests

We declare no competing interests.

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