Overweight Mothers with Stunted Children: A Nutrition Paradox

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ABSTRACT
This paper investigates prevalence of stunted child-overweight mother pairs using cross-sectional data (N=89,941) from 17 Low- and Middle-Income Countries. We examine the association of this 'Double Burden of Malnutrition' (DBM) with wealth, urbanisation and education. DBM is present in roughly 7% of all households studied. Pooled logistic regressions reveal that the probability a child-mother pair exhibits DBM increases as the mother is older and less educated, the child is older and male, and the household is larger, wealthier and urban. However, 78% of all sample variation in DBM is attributable to unmeasured country-specific factors, possibly including cultural and policy influences.

Keywords
Double burden of malnutrition, LMIC, nutrition transition, household economics, cross-country analysis.

INTRODUCTION
Preventing undernutrition of children in low- and middle-income countries (LMIC) has long been a worldwide development goal. While progress is being made, worldwide prevalence of undernutrition remains high. In 2015, 156 million children under the age of five were stunted (low height-for-age) according to the World Health Organization (WHO). Recently, global concern is shifting towards the other end of the nutrition spectrum: overweight and obesity are increasingly prominent among adults, even in LMIC. Worldwide, over 1.9 billion adults are overweight, and many of them live in LMIC [14]. Malnutrition, both underweight and overweight, has negative economic consequences. It leads to poor health, which raises health care costs and reduces productivity [14]. It can create a poverty trap: poverty leads to malnutrition, which reduces productivity and this further exacerbates poverty [9].

The WHO defines the Double Burden of Malnutrition (DBM), or the Nutrition Paradox, as "*the coexistence of undernutrition along with overweight and obesity, or diet-related noncommunicable diseases, within individuals, households and populations, and across the lifecourse*" [14]. Understanding the DBM phenomenon is essential to design the appropriate policy response to both child undernutrition and adult overweight. The provision of extra nutrition to a household with undernourished children could have negative health consequences if overweight parents live in the same household. Conversely, programmes that encourage overweight parents to eat less could impact negatively on their underfed child. A general broad-brush nutrition policy is not suitable in the presence of DBM. The coexistence of under- and overweight individuals within the same households calls for individual-targeted policy design [3; 5; 7]. Furthermore, the DBM phenomenon suggests that maldistribution, and not shortage, of resources is the root of the nutrition problem. Redistributing (healthy) food within a household may achieve better nutritional outcomes than simply offering more food to households [3]. Examination of DBM can provide valuable insights into the impact of economic growth and urbanisation on populations through the nutritional transition [13].

This paper documents and seeks to explain the coexistence of an undernourished child and an overweight mother within the same household using comparable data from 17 LMIC. Examination of child-mother pairs focuses on the most extreme form of the DBM phenomenon: two closely related individuals who share many common genes and would be expected to share resources nonetheless are observed with diametrically opposite nutritional outcomes [5; 7]. Therefore, the following question will be addressed:

How does the prevalence of stunted child-overweight mother pairs vary with wealth, urbanicity, and maternal education within LMIC?

Previous research has found that the prevalence of DBM has an inverted U-relationship with household wealth within a country [3; 5]. We examine whether these relationships continue to hold in a pool of LMIC using the most recently available data that are highly comparable across a large number of LMIC. How prevalence differs between urban and rural locations is far less clearly established [3; 5]. Also, when DBM is defined as an undernourished child with an overweight mother, the association with maternal education remains unclear. Jehn and Brewis found that the relative risk of DBM decreases with the mother's level of education [7], whereas Wojcicki found no clear association [13]. Variation with maternal age has been investigated only through differences across a binary distinction between younger and older mothers [7]. By using the most recent datasets (all post-2010), we can investigate whether the prevalence of DBM remains low in sub-Saharan Africa [13] after a period of rapid economic growth in the region.

We estimate DBM prevalence to be around 7% across the 17 countries. The probability of DBM is larger for older and less educated mothers, older and male children, and larger, wealthier and urban households. However, these child-mother-household characteristics only partially explain DBM variation. The greater part of the variation is accounted for by country-specific factors, which may

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include cultural and policy determinants of nutrition.

The next section uses insights from the literature to propose hypotheses. Data sources, measurement of key variables and regression methods are described in the third section and the results are presented in the fourth. The paper concludes with a discussion of the implications and limitations of the analysis.

THEORETICAL FRAMEWORK

We suppose that three factors are particularly important for understanding the prevalence of the double burden of malnutrition: wealth, urbanisation, and education.

Contrary to other forms of malnutrition, DBM combines the 'bads' of both undernutrition and overweight [3; 5]. This complicates the relationship with wealth: households must be rich enough for the mother to become overweight, but still poor enough for the child to be left undernourished. Rapid economic development and westernisation of culture, including eating habits, often influence only part of society [3]. This makes LMIC, but not the lowest income countries, the perfect location for the phenomenon of DBM.

H1: There exists an 'inverse U-relationship' between prevalence of DBM and household wealth.

Economic development is accompanied by increasing urbanisation as people leave the countryside to live and work in cities [5]. Many gain access to high-fat and innutritious fast foods, leading to increased obesity rates [3; 5]. The changing structure of employment also contributes to obesity through reduced physical exercise, as people, women in particular, move from arduous physical work on the land to less physically demanding work in cities [5]. It is plausible that women who work long days for low wages are more likely to consume relatively cheap and easily accessible low-nutrition foods. They may insufficiently adjust their calorie intake to correspond to their reduced need for energy. This process of a shift in diet and decreased physical exercise is captured by the concept of nutritional transition [8].

H2: The prevalence of the DBM is positively associated with urban location of a household.

Well-educated parents tend to have better paid jobs and tend to be more aware of nutritional needs, making them more inclined to purchase quality food, leading to better nutrition of both the child and the mother [7]. Conditional on wealth, maternal education may be expected to induce better nutrition choices.

H3: There exists a negative relationship between DBM and maternal education.

It is important to recognise that there are many potential explanations for DBM that we cannot test. For example, a variant of the 'foetal origins hypothesis'[1], which operates through early life undernutrition impairing capacity for fat oxidation and has some empirical support, suggests that the mother's overweight is a direct consequence of her own stunting as a child [1]. In that case, misallocation of resources would not be the root of the problem.

DATA & METHODOLOGY

Data were obtained from the Demographic and Health Surveys (DHS), which collect nationally representative individual health data in over 90 developing countries [11]. We used data from surveys conducted in 17 LMIC between 2010-2014 (see Table 1). Each dataset includes observations (N≈1,700-13,000) on children aged under five, along with information on their mothers and households. In total, we observed 89,941 pairs of children and non-pregnant mothers across the 17 LMIC.

The explanatory variables are: child's age, child's gender, mother's age, mother's education, household size, urban/rural, and wealth quintile group. The latter is formed from a principal components analysis of various indicators of household wealth [4]. We include a dummy for each country but for Ethiopia, which has the lowest DBM prevalence and is taken as benchmark.

For each child, we define a binary indicator of DBM equal to 1 if the child is stunted and its mother is overweight [3; 5; 7; 13]. Stunting is defined as a height-for-age Z-score below -2 [14].[2] The reason to focus on height-for-age, like Garrett and Ruel, rather than weight-for-age of the child is because the former is an indicator of cumulative and irreversible undernutrition, whereas low weight-for-age could be temporary [5]. Maternal overweight is defined as Body Mass Index (BMI) > 25.0 [14], except for Nepal and Cambodia where we set the threshold at 23.0 following recommendations of the Chinese Community Health Resource Center [2].

We identify factors that are associated with variation in the incidence of DBM across households by estimating logistic regressions of this outcome. That is, we estimate:

$$Pr(DBM_i = 1) = \frac{\exp(x_i{}'\beta)}{1 + \exp(x_i{}'\beta)}$$

where $Pr(DBM_i = 1)$ denotes the probability that in a child-mother pair *i* the child is stunted and the mother is overweight. The explanatory variables are collected in the vector x_i. Squared terms were included for maternal and child age to test for possible non-linear relationships. Marginal effects on probability are reported, defined for continuous regressors as:

$$\frac{\partial Pr(DBM_i = 1)}{\partial x_{ji}} = Pr(DBM_i = 1) \cdot Pr(DBM_i = 0) \cdot \beta_j$$

The marginal effect for a discrete regressor is the difference in the estimated probability evaluated with the coefficient of that variable included in the linear index $x_i{}'\beta$, less the estimated probability evaluated without that coefficient. We report the average of the marginal effects (AME) over all observations [6].

To evaluate model performance, we do not rely on the

[1] This could be explained by irreversible changes in the metabolic system. Genes that are responsible for optimal extraction and conservation of nutrients are activated in infanthood; as they remain active even as food supply is sufficient, this leads to increased risk of overweight [1].

[2] $Z = \frac{observed\ value - mean\ value\ of\ reference\ population}{standard\ deviation\ value\ of\ reference\ population}$ [11]. For more information about the interpretation of Z-scores, see WHO [14].

pseudo-R^2 because this is often low for regressions of cross-sectional data. One cannot expect to explain a large proportion of the large variation observed across individuals. Joint significance of variables is analysed through LR-statistics, and model hit rates[3] are used to select an appropriate specification.

RESULTS

Most countries have a DBM prevalence of about 5%, averaging at 6.9%. This rate is in line with previous research [5, 13]. Egypt and Peru stand out with prevalence rates of 15.4% and 10.9% respectively. The remarkable prevalence rate in Egypt was also found by Garrett and Ruel [5].

Table 1 shows the pooled logistic regression results. The significance and substantial magnitudes of all the country indicators imply that DBM prevalence continues to vary greatly by country after controlling for cross-country differences in the socio-demographic variables included in the regression, e.g. age, education, child gender, household wealth. Corresponding to the high prevalence rates, the largest marginal effects are found for Egypt and Peru. Regressing DBM prevalence on the country-specific effects gives an R^2 of 0.78, indicating that the covariates account for just over a fifth of the variation in DBM.

Conditional on the country-specific effects, all the AME are significantly different from zero. On average, DBM probability is increasing with the child's age. This average effect is calculated from a non-linear relationship in which the DBM likelihood is increasing with age at a decreasing rate. The DBM probability is maximised at the age of 32.5 months. This nonlinear relationship is consistent with evidence on the variation in the rate of child stunting with the child's age [10]. Male children have a probability of DBM that is 1.3 percentage points higher than that for girls. This effect is relatively large compared to the average DBM prevalence rate of 6.9% across all countries. It corresponds to findings that the probability of stunting in sub-Saharan Africa is higher for boys than for girls [12].

Maternal age shows a similar relationship with probability of DBM as the relation between the child's age and DBM. The probability is increasing with the mother's age over most of the age range, reaching a maximum at 41.4 years, which corresponds approximately to the 95th percentile of the distribution. The positive relationship is supported by empirical evidence that risk of overweight increases with age in women [7]. An extra year of maternal education is associated with a fall in the probability of DBM of 0.22 percentage points. Hence, a woman who has completed a primary education (5 years) has a 1 percentage point lower probability of DBM compared to an uneducated woman, which is a strong effect compared to overall prevalence. This is consistent with hypothesis H3.
The probability of DBM for urban households is 0.91 percentage points higher than for rural households, in line with hypothesis H2. DBM likelihood rises with wealth.

The difference between the top and bottom wealth quintiles is 3.8 percentage points, over half of the average prevalence rate. We do not find evidence of an inverted U-

Table 1: Logistic regression for DBM of child-mother pair (pooled regression for 17 countries)

Variable	AME	Std. Err.	P > Z
Mother age (yrs)	0.002001	0.000128	0.000
Mother education (yrs)	-0.002180	0.000217	0.000
Child age (mths)	0.000189	0.000039	0.000
Child gender	0.013147	0.001659	0.000
Household size	0.000748	0.000333	0.025
Household wealth quintile			
2nd Poorest	0.023703	0.002686	0.000
Middle	0.027128	0.002973	0.000
2nd Richest	0.026471	0.003370	0.000
Richest	0.038067	0.005632	0.000
Urban household residence	0.009171	0.002061	0.000
Cambodia	0.163779	0.018718	0.000
Dominican Republic	0.115155	0.019869	0.000
Egypt	0.338262	0.021375	0.000
Ghana	0.112979	0.019435	0.000
Haiti	0.128223	0.018662	0.000
Jordan	0.167116	0.020335	0.000
Kenia	0.165677	0.016593	0.000
Liberia	0.180656	0.021098	0.000
Mali	0.131049	0.018065	0.000
Namibia	0.217166	0.026868	0.000
Nepal	0.087170	0.020667	0.000
Peru	0.314150	0.019591	0.000
Rwanda	0.219185	0.021098	0.000
Sierra Leone	0.188020	0.019904	0.000
Zambia	0.237253	0.018570	0.000
Zimbabwe	0.304075	0.023010	0.000
Log likelihood	-21,079.19		
LR-statistic, $Chi^2(28)$	3,111.92		0.000
Pseudo-R^2	0.0687		

shape (hypothesis H1); the probability increases almost monotonically as household wealth grows. DBM probability only mildly increases with household size.

As expected given the cross-sectional nature of the data, the pseudo-R^2 of 0.0687 is low. The LR-test strongly rejects overall insignificance of the model.

Using a threshold of 0.0693, the overall sample prevalence rate, the relationship between a 'true' DBM child-mother pair and a DBM household predicted by the model was evaluated. Both sensitivity and specificity of the model are relatively high (over 65%), so the model correctly classifies in almost two thirds of all cases. However, due to the low base rate of DBM (only 6.9% of all households), there is a high likelihood of a non-DBM observation even if the model points towards DBM.

[3] A hit rate is defined as the fraction of correct predictions in the sample. In mathematical notation: $h = \frac{1}{N}\sum_{i=1}^{N} w_i$, where w_i is an indicator function equal to 1 if the observation is predicted correctly, so if $y_i = \hat{y}_i$ [6].

CONCLUSION & DISCUSSION

The average DBM prevalence rate among all child-mother pairs studied is 6.9%. Conditional on country-specific effects, the pooled logit regression indicates that DBM likelihood increases as the mother is older and less educated, the child is older and male, and the household is larger, wealthier, and urban. Especially the impact of household wealth is strikingly large. Despite this large effect, a U-relationship was not established, but a linear increasing relationship instead. The fact that only quintiles have been used can be limiting to the research, therefore future research could examine the behaviour of the wealth effect more closely by using for example a continuous variable or a larger number of quantiles. The covariates explain barely a fifth of the variation in DBM; the remainder is explained by country-specific effects. This implies that DBM likelihood is highly dependent on the country-specific base rate, which absorbs e.g. sociodemographic, cultural, and political factors. Future research should examine the origin of these particular effects. It is also of interest to examine whether relations between these effects exist.

We emphasise that the correlations found should not be interpreted as causal relationships. The latter could be interesting for future studies, but would require adequate instrumental variables. Additionally, our data, although the best available to assess child and mother nutritional status across countries, might be subject to measurement error, which justifies extra prudence in drawing quantitative conclusions. Finally, we were constrained by the variables available in the datasets. We believe that the influence of factors such as dietary habits, nutrition intake, food availability, general health trends, climate, policy, and cultural differences deserves attention in follow-up research, though these variables may be hard to quantify.

Summarising, our results show that the DBM remains a remarkable phenomenon and its prevalence calls for well-considered nutrition policies. Our pooled model can serve as a tool to assess the preliminary likelihood that a household is subject to the DBM. The significant presence of country-specific effects underwrites the importance of locally designed nutrition policies and an individual approach for DBM household members. We believe that better understanding of this phenomenon will lead to a healthier global population.

ROLE OF THE STUDENTS

As the authors expressed their desire to investigate a yet unsolved paradox in the field of health economics, prof. dr. O. A. O'Donnell suggested to examine the Double Burden of Malnutrition. Christiaan performed most of the literature review and explored the theoretical background; Sebastiaan performed the regression analysis. Subsequent analysis and interpretation of the results was a joint effort of the authors.

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